

BEACH EROSION CONTROL REPORT
ON COOPERATIVE STUDY OF
METROPOLITAN DISTRICT COMMISSION BEACHES
MASSACHUSETTS

PART C

QUINCY SHORE BEACH

JUNE 1, 1949



CORPS OF ENGINEERS,

U. S. ARMY

OFFICE OF THE DIVISION ENGINEER

NEW ENGLAND DIVISION, BOSTON, MASSACHUSETTS

QUINCY SHORE BEACH

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BEACH EROSION CONTROL REPORT ON COOPERATIVE STUDY OF
METROPOLITAN DISTRICT COMMISSION BEACHES, BOSTON, MASSACHUSETTS

INTRODUCTORY

The cooperative study of Metropolitan District Commission Beaches in Metropolitan Boston, Massachusetts, comprises studies of five beaches which are essentially independent of each other in so far as the scope of the study is concerned. The cooperating agency stated its objective in the prosecution of the study to be the determination of the best method of preventing further erosion, stabilizing and improving the beaches and protecting the sea-walls. Report on studies of Winthrop Beach was made by the Beach Erosion Board and submitted to Congress December 9, 1948. Report on the remaining beaches is made in four parts, as follows:

- A. Lynn-Nahant Beach
- B. Revere Beach
- C. Quincy Shore Beach
- D. Nantasket Beach

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SYLLABUS - QUINCY SHORE BEACH

The Division Engineer finds that Quincy Shore Beach is an artificial beach resulting from highway construction over a former marsh area; that the beach is inadequate for recreational purposes, is eroding and is endangering the existing sea-walls and highway embankments; and that the stepped sea-wall is inadequate in resisting attacking forces and in protecting the highway and adjacent property. The Division Engineer recommends as the best method of improving the beach, arresting erosion, protecting sea-walls and adjacent highway and property, between Hovey Street and Rufe's Hummock Sea-wall, a distance of 8500 feet, the raising of the back shore to elevation 15.0 feet above mean low water with artificially placed fill, the construction of a concrete-encased steel sheet-pile bulkhead having a top elevation of 18.0 feet above mean low water for 4750 feet between the parapet wall and National Sailors' Home Hill Sea-wall, the construction of a concrete sea-wall having a top elevation of 19.2 feet above mean low water for a distance of 325 feet northward of the parapet wall to Billings Street, the construction of two 350-foot long impermeable, stone groins adjacent to the yacht clubs, the construction of a walk behind the recommended bulkhead, and the construction of a culvert at Sachem Creek and extensions of drains across the beach, all at an estimated cost of \$849,000 and \$7,000 annually for maintenance.

The Division Engineer recommends that the Commonwealth of Massachusetts adopt a project for the recommended work and that the United States participate in this project by contributing funds in an amount equal to one-third of the cost of construction of new work, estimated to be \$283,000, subject to certain specified conditions.

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON, MASS.

June 1, 1949

SUBJECT: Beach Erosion Control Report on Cooperative Study of
Metropolitan District Commission Beaches, Boston,
Massachusetts: Part C - Quincy Shore Beach.

TO: The Chief of Engineers
Department of the Army
Washington 25, D. C.

I. GENERAL

1. Authority. - A formal application from the Metropolitan District Commission of the Commonwealth of Massachusetts, dated August 9, 1945, for a cooperative study of beach problems within the Metropolitan District in the vicinity of Boston, Massachusetts, including Lynn-Nahant Beach, Revere Beach, Winthrop Beach, Quincy Shore and Nantasket Beach, and providing for prosecution jointly by the Metropolitan District Commission and the United States was approved by the Chief of Engineers, United States Army, October 2, 1945, in accordance with the authority conferred by the provisions of Section 2 of the River and Harbor Act approved July 3, 1930 and Public Law 166, 79th Congress, approved July 31, 1945.

2. At the request of the Metropolitan District Commission, the study of Winthrop Beach was given priority over the study of other beaches to allow a separate report to be made on Winthrop prior to completion of the entire study. A report, "Beach Erosion Control Study, Winthrop Beach, Mass.", was made by the Beach Erosion Board and submitted to Congress December 9, 1948, and is published in House Document No. 764, 80th Congress, 2nd Session.

3. Purpose. - The purpose of the investigation of the general study of Metropolitan District Beaches is to determine the best method of preventing further erosion, stabilizing and improving beaches, and protecting the sea-walls.

4. Prosecution of the Study. - The Commonwealth of Massachusetts, through the Metropolitan District Commission, contributed one-half the cost of the study. The field work and collection of basic data for the study were carried out by the District Engineer, Boston, Massachusetts, with the exception of economic data, which was collected by the cooperating agency. A geological study of the area except the mainland section of the Lynn-Nahant Beach was prepared by the United States Department of the Interior, Geological Survey, under a cooperative geological project of the Massachusetts Department of Public Works. The report on Winthrop Beach was prepared by the Beach Erosion Board. The report on other beaches included in the study has been prepared by the Division Engineer, New England Division.

5. Preparation of Reports. - The five beaches comprising the study, in so far as their physical location and the scope of the study are concerned, are independent shore units which may properly be treated as separate beaches. A separate report has been prepared on Winthrop Beach. The report on the remaining beaches has been divided into four parts, as follows:

- Part A - Lynn-Nahant Beach
- Part B - Revere Beach
- Part C - Quincy Shore Beach
- Part D - Nantasket Beach

Each of the four parts is issued as a complete report for the subject beach, and contain general paragraphs numbered 1 to 5, inclusive, and Plates 1 and 2, which are common to all four parts.

II. DESCRIPTION

6. Location. - Quincy Shore Reservation Beach is in the City of Quincy, Norfolk County, Massachusetts, at the head of Quincy Bay in Boston Harbor, 6 miles southeast of the City of Boston. (See Plate I, U. S. Coast and Geodetic Survey Chart No. 246, and U. S. Geological Survey Boston Quadrangle.)

7. General Description. - The beach at the head of Quincy Bay is approximately 2-1/2 miles long extending between two headlands, Hough's Neck on the southeast and Squantum on the northwest. The entire shore is under the jurisdiction of the Metropolitan District Commission and is officially divided between two reservations, Quincy Shore Reservation, extending from Squantum to a point about 500 feet southerly of Fenno Street, and Furnace Brook Parkway, extending from the limit of Quincy Shore Reservation to Hough's Neck. The study area comprises the southerly 6700 feet of the Quincy Shore Reservation. The present beach is the result of the realignment of the original irregular shore line by the construction of the Shore Drive over beaches, marsh lands and higher glacial deposits.

8. The coast of Quincy Shore Reservation has been developed as a densely populated urban, middle class, residential area. This residential area extends back across the city without interruption. The land immediately adjacent to the shore drive, between Channing Street and Rice Road, See Figure C-4, is used for commercial purposes, containing stores, a gasoline station, restaurants, ice cream stands and cafes. There is one large bowling alley at Sachem Creek. There are two large yacht clubs adjacent to Sachem Creek, the Wollaston Yacht Club on the southerly side and Squantum Yacht Club on the northerly side. Each club maintains a pier which projects about 350 feet into the bay to the head of a state maintained yacht basin and channel. There are no storage yards connected with these clubs. The coast immediately adjacent to Furnace Brook Parkway is tidal marsh which fronts high ground used for residential and park purposes. There are no public bathhouses along this beach.

9. The Metropolitan District Commission Reservation comprises a narrow public beach, which is generally covered at high tide, sea-walls and riprap shore protection, parking areas and a boulevard. The shore of the study area is lined with concrete sea-walls except at the southerly end, where four hundred feet of riprap has been placed. Outside of the study area the shore is generally protected with riprap paving. The beach is generally of coarse sand and gravel above mean tide level and mud below that elevation. The offshore area is very flat and shoal, except in the dredged yacht channel, and at low tide large clam flats and tidal islands are exposed. The ten-foot contour is generally in excess of 5000 feet off shore.

10. The entire area is traversed by a boulevard which by-passes business sections of the city of Quincy located on main state highway routes, and is used as the principal traffic artery to areas south of the city of Boston. Free public parking is provided along the entire length of the beach on a parking strip between the highway and sea-wall. Bus service is provided within 800 feet of the beach by a system serving the entire area south of Boston and connecting with the rapid transit terminals of the Metropolitan Transit Authority in Boston. The beach is open to the public free of charge and life guards and policing are provided. The extensive use of the beach by bathers from nearby homes and by those who come in autos and buses in their bathing suits, creates crowded conditions on summer weekends and hot nights. The daily attendance at this beach averages 1000 persons and the attendance on Sundays and holidays increases to 3000 to 5000 persons.

III. GEOLOGY

11. Classification of Beach. - Quincy Shore Beach is a bayside beach on the southwestern side of Quincy Bay. Its southeastern end projects into Black's Creek and its northwestern end is attached to the marsh southwest of Squantum.

12. Bed Rock. - Bed rock crops out at Squantum and adjacent North Quincy. Beach material has not been derived directly from bed rock.

13. Surficial Deposits. - a. Till. - Till (boulder clay, "hard pan") is found immediately behind the beach at two places, one being in the vicinity of Profile A-2 and the other in the vicinity of Profiles C and E. The till is a compact, unstratified, surficial deposit containing angular and sub-angular fragments varying in size from clay to boulders. This till was deposited by the continental glacier which disappeared from the Boston area approximately 30,000 years ago. A small cliff has been cut in Rufe's Hummock,* which is composed of till. A narrow beach lies in front of the

* The name "Rufe's Hummock" as used in geological reports applies to a hummock designated as such on the Boston Quadrangle, U. S. Department of Interior Geological Survey, located between Profiles I and J. Plans of the Metropolitan District Commission and other agencies call the area "National Sailors Home Hill" and apply the name "Rufe's Hummock" to a point 500 or more feet south of Profile K. The Metropolitan District Commission designates two sea-walls by these names. In this beach erosion report, the name "Rufe's Hummock" has been applied to the location designated on Metropolitan District Commission Plans, except in sections dealing with geology. In geology, the name is applied to the location shown on geological plans.

cliff, and a boulder pavement extends beyond the beach for a hundred feet or more. Waves and currents have deposited the clay and silt sizes of the eroded till in Quincy Bay; the boulder sizes are now in the pavement; and the intermediate sizes were used in the construction of that part of the beach which is in front of and to the southeast of Rufe's Hummock. In no other area has till been an important source of beach material, as the waves and currents in Quincy Bay have always been weak and the till has been protected by marsh deposits and sea-walls.

b. Outwash Sands and Gravel. - Glacial outwash sand and gravel occurs immediately in back of the beach at two places, one being north of Profile A-3 and the other being between Profiles A-1 and B. It is a stratified, unconsolidated, surficial deposit containing sand and gravel. It was deposited by streams flowing from the continental glacier. This glacial outwash has never been an important source of beach material as it has been protected from marine erosion by marsh deposits and sea-walls.

c. Marshland. - Marshland, underlain by peat, is common along the entire beach. A geologic map developed prior to 1905 by Laforge, before the construction of the present shore line boulevard and structures, indicates that all surficial deposits except Rufe's Hummock were practically entirely separated from the bay by marshlands. The peat underlaying the marshland is composed of clay, silt and organic matter and was deposited when sea level was at or near its present position. Beach material has not been derived from the peat.

d. Beaches. - The geologic map developed by LaForge also shows that prior to 1905 no beach existed northwest of Rufe's Hummock (northwest of Profile I). The highway was built in 1905, sea-walls were constructed in 1910 at Profile J and at a point about 500 feet south of Profile K, and the principal sea-wall was constructed in 1926 between Profiles A-3 to I.

Nearly all the material northwest of Rufe's Hummock was artificially deposited during these engineering operations and the beach southeast of the hummock has been somewhat modified by these operations. Quincy Shore Beach, is, therefore, mainly artificial. It is underlain by bedrock, till, outwash sand and gravel, and marsh deposits.

14. Geological History. - a. The till and outwash are the oldest surficial deposits in the area, although they are younger than the bedrock which underlays the area. Sea level stood at approximately its present position shortly after the deposition of the till and outwash. Following a short interval at this stand, sea level dropped slowly to a point scores of feet lower than the present position and at this time the shore line was several miles northeast of the present beach. After a period of unknown length, the sea rose from this low level and the shore line moved southwestward. When the sea reached a level at or near its present position, deposition of peat and erosion of the till at Rufe's Hummock began. Material eroded from Rufe's Hummock, together with that obtained from offshore areas, was deposited by waves and currents to form the southeast part of Quincy Shore Beach.

b. That part of Quincy Shore Beach which is northwest of Rufe's Hummock was artificially constructed subsequent to 1905 and the material in it has been redistributed by waves and currents. The absence of a naturally formed beach in this area was not due to a lack of source of material but to the weakness of the waves and currents in Quincy Bay.

IV. FACTORS AFFECTING SHORE PROCESSES

15. Composition of Beach. (Figures C-1 to C-4). - The beach adjacent to the sea-wall consists of sand and gravel in varying proportions. The foreshore about 100 feet from the sea-wall is muddy. The following notes indicate the composition of the beach on June 16, 1946.

*a. In Profile A area, (See Figure C-1) the beach is hard-packed sand containing a few stones. There are some areas of peat between the profile and the new drain outfall at Profile A-1. North of the outfall structure, the beach becomes more stony. Near the profile, the beach is 4 to 5 feet below the top of the toe wall.

b. In Profile B area, the elevation of the beach is higher than at Profile A. The backshore area north of Squantum Yacht Club is firmly-packed sand near the wall but is stony 15 to 20 feet from the wall. Two clumps of eel grass grow in the area, one being on the profile itself and the other at the foot of Apthorp Street. The beach elevation at the wall is about 2-1/2 feet below the top of the toe wall. The Yacht Club pier does not appear to have had any effect upon the beach formation.

c. Between Squantum Yacht Club and Profile C at Sachem Creek (See Figure C-2), the beach is generally 2 to 2-1/2 feet below the top of the toe wall. Between the Squantum Yacht Club and the Sachem Creek bar, there is a good, medium sand beach which supports two areas of eel grass. The Sachem Creek bar commences to form at about the midpoint between the Squantum and Wollaston Yacht Clubs.

d. At the Profile C area (See Figure C-2), the beach is covered with a bar of soft sand containing a moderate amount of fine stone. A new channel for Sachem Creek was cut across this bar by a bulldozer in early May. The new channel is about 4 feet wide and extends from the northerly half of the bridge opening, leaving the southerly half of the opening closed by the bar. Prior to this, the bar closed the mouth of the creek leaving a small channel running northward between the bar and the wall. The contours of the new channel have been smoothed out to curve toward the bridge. The beach elevation is at the top of the toe wall on the north side of the creek and at the top of the top step on the south side of the creek. The crest of the bar is about 1 foot higher than beach elevations at the wall and is from 20 to 25 feet from the wall. The northerly side and top half of the bridge opening is spalled and rounded, indicating a long, continued flow through the bridge into a channel running northerly along the face of the wall. The stream at the time of inspection had no current.

e. The Wollaston Yacht Club pier does not appear to have had any effect upon the beach formation. Beach elevations are slightly higher at the curved walls at the Sachem Creek bridge opening, but this effect is believed to be a feature of the bar formation. Starting at Sachem Creek bar, the high water line moves out 25-30

feet from the wall and stays at about this location to a point near Profile F. On the southerly side of Wollaston Yacht Club, the beach covers the toe wall for the 20 feet adjacent to the pier and then drops to an elevation which is about 1 foot below the top of the toe wall. The beach has a crest about 12 to 15 feet from the wall which is 1 foot higher than the beach elevation at the wall.

f. In Profile D area (See Figure C-3), the beach elevations have been raised to an elevation near the top of the toe wall. Traces of a gully noted in this area during December 1945 can still be found. It shows as a shallow area 4 feet wide, 25 to 30 feet long and 8 to 12 inches deep. The beach material is coarse sand and gravel which compacts to a smooth surface.

g. In the Profile J area (See Figure C-4), the beach is coarse sand and is 6 to 8 feet below the top of the wall.

h. In the Profile K area, the beach is composed of medium firmly-packed stones.

i. At Rufe's Hummock Sea-wall, about 500 feet south of Profile K, the beach is stony and is 5 feet below the top of the wall.*

16. On December 4, 1945 after the storm of November 28-30, there was a gully formed at the base of the wall between Profiles F and D. The gully was 6 to 12 inches deep varying up to 5 feet in width. It has been reported that this gully forms every year and is filled each spring by packing beach materials against the wall with power equipment. The November storm resulted in a 2 to 3 foot lowering of beach elevation adjacent to the wall.

17. During the late summer of 1948, the Metropolitan District Commission spread approximately 6400 cubic yards of sand over the beach from a point near Atlantic Street to about Apthorp Street with the greatest amount of the sand being placed in the area between Atlantic Street and Hollis Avenue. The resultant layer of sand was only 2 to 3 inches thick. The upper picture in Figure C-1 shows the area sanded as it appeared in the following March.

18. Channel and Mooring Basin. - The channel and mooring basin for the yacht clubs have been dredged and redredged by the State of Massachusetts at frequent intervals, but it has never maintained its project depth. In

1912 the channel and basin were dredged to a project depth of 3 feet below mean low water. At this time, a 100-foot wide basin was extended 180 feet along the north side of the Wollaston Club and there was no basin in front of that club. The basin along side the Wollaston Club filled within three years to elevation above mean low water. In 1915 and 1916, the channel and basin between the two clubs were dredged to a project depth of 8 feet below mean low water. The mooring basin was dredged to a project depth of 8 feet in 1921 and extended in front of the Wollaston Club to a point 75 feet south of the club. In 1929 the channel and mooring basin was dredged to a lesser project depth of 6 feet below mean low water. The basin and a part of the channel was dredged again in 1933 and 1937 to a project depth of 6 feet below mean low water. In 1946 the channel was dredged to a project depth of 6 feet below mean low water and the mooring basin to a project depth of 8 feet below mean low water. At the time of each dredging the channels and basin had filled in for depths of several feet. Basin soundings after dredging in 1937 generally varied between 6.0 and 7.8 feet below mean low water and prior to dredging in 1946 generally varied between -0.8 and 1.8 feet below mean low water. Channel sounding in 1937 varied between 6.0 and 9.5 feet below mean low water, and in 1946 varied between 2.0 and 5.6 feet below mean low water. Materials dredged in 1946 were mud and clay. The constant need of dredging of the channel and mooring basin indicates that there is considerable material moving along the offshore bed of Quincy Bay.

19. Borings and Probings. - Borings were taken at the four corners of Sachem Creek Bridge prior to its construction in 1905. On the seaward side of the bridge there were 8 to 9 feet of mud and sand overlaying 7 to 9 feet of varying strata of sand and gravel and of fine sand, which in turn overlay clay which occurred 10 to 13 feet below mean low water. On the

land side of the bridge 4 to 6 feet of mud, sand and gravel overlay 4 to 6 feet of clay and 3 to 6 feet of fine sand which in turn overlay mixtures of sand, clay, gravel and rocks which occurred 5 to 8 feet below mean low water. Probings taken by hand bar on June 20, 1946 at Profiles A, C, G and K attained penetrations of 3.5 to 7 feet. The materials were estimated as sand, gravel and clay. The locations of the probings are shown on Plate C-1.

20. Beach Materials. - Samples of the top two inches of materials at about mean tide elevation were taken on June 20, 1946 at Profiles A, C, G and K and on August 16, 1946 at Profile A-2. The locations of the sampling points are indicated on Plate C-1. The materials at Profiles A and A-2 varied from medium gravel to silt and at Profiles C, G and K varied from large gravel to very fine sand. The median diameters were found to be as follows:

<u>Profile</u>	<u>Median Diameter (mm)</u>
A-2	0.08
A	0.10
C	1.9
G	4.5
K	5.5

21. Wind. - A wind diagram compiled from observations of the U. S. Weather Bureau at Boston, Massachusetts, 1927-1937, and the yearly cumulative average ocean winds compiled from records of the U. S. Navy Hydrographic Office for the 5-degree squares nearest Quincy Shore Beach and other Metropolitan District Beaches are shown on Plate 2. These two diagrams indicate that, of the winds which blow over significant fetches of ocean before reaching the area, those from the northeast quadrant are prevailing and predominant. Quincy Shore lies perpendicular

to the prevailing wind direction and is directly in line with the entrance to the harbor. Moderate protection from the winds is afforded by the headlands forming the entrance of the harbor and the islands within the harbor.

22. Tides. - The mean range of tide at Quincy Shore Beach, computed from the accepted value at Boston, Massachusetts, by application of a factor determined by the U. S. Coast and Geodetic Survey, is 9.1 feet. The heights of extreme tides have not been recorded at Quincy but those observed over a long period of record at Boston Harbor provide an excellent indication of the magnitude of fluctuations from the mean. At Boston Harbor the predicted spring tides range up to 12.0 feet and actual heights of extreme tides have been recorded up to 15.0 feet above mean low water.

23. Storms and Their Effects. - The paths of all hurricanes (defined as those with a central pressure of 29.0 inches or lower, and winds near the center of more than 60 miles per hour in some points in the path) which have struck within a 150-mile radius of Quincy Shore Beach between the years 1874 and 1944 have been extracted from the book, "Hurricanes," by Ivan R. Tannehill and various other sources and plotted on Plate 2. An examination of this plate shows that between 1874 and 1945, a period of 71 years, 32 tropical storms of hurricane intensity have passed within a 150-mile radius of the beach.

24. A summary of the record of winds of gale force or greater, compiled from records of the U. S. Weather Bureau at Boston, Massachusetts, covering the 75-year period 1870 to 1945, inclusive, is given in the following table:

DIRECTION OF GALES

1870-1945 (incl.)

<u>Direction</u>	<u>Number of Gales</u>	<u>Percent of Total Gales</u>
North	3	2
Northeast	80	50
East	9	6
Southeast	14	9
South	12	7
Southwest	15	9
West	13	8
Northwest	14	9
	160	100

25. The following table, based upon the gale record summarized above, indicates the number of days that gales from various directions may be expected during a 100-year period.

GALE FREQUENCY BY DIRECTION

	<u>N.</u>	<u>N.E.</u>	<u>E.</u>	<u>S.E.</u>	<u>S.</u>	<u>S.W.</u>	<u>W.</u>	<u>N.W.</u>	<u>TOTAL</u>
Number of days observed 1870 to January 1946	4	131	9	15	12	20	16	18	225
Frequency in days per 100 years	5	175	12	20	16	27	21	24	300

During a 100-year period 175 gales, comprising 58 percent of all gales, may be expected from the northeast while only 32 or 11 percent of all gales may be expected from both the east and southeast.

26. Storm damage along Quincy Beach results from the action of wind-driven waves and their induced currents, and its severity is directly dependent upon the velocity and direction of the wind and the tidal stage during the storms. Northeast storms have a perpendicular approach to the entrance of Boston Harbor and Quincy shore lying directly in back of the entrance is in the direct line of approach of all such storms sweeping into the harbor. The fury of the attack on the shore is moderated by the islands in the harbor entrance and the shoals in front of the beach.

27. Quincy shore is defined by a low highway embankment generally located over former beaches and marsh areas. The face of the embankment within the study area is generally lined by a low sea-wall; outside of the study area it is generally protected by riprap. The top elevations of the wall and bank are generally just above predicted Boston Harbor spring tide high waters of 12 feet and in part below the recorded extreme tides of 15 feet above mean low water. Normal high waters rise against the wall and extreme waters almost over-top the wall. Storm winds carry the wave wash over the wall onto the highway, creating dangerous traffic conditions and often making the highway impassible. This flooding results in numerous washouts behind the wall with the washouts being generally confined to the areas reserved for parking. During severe storms the wave wash is carried over the highway to inundate adjacent low lying residential areas and to cause washouts on the landward side of the embankment. The impact of storm waves on the wall results in the spalling, cracking, and breaking of the concrete.

28. The following report of damage resulting from the storm of April 20-22, 1940 was prepared by the U. S. Engineer Office, Boston and is based upon field inspection and press reports.

*(a) Northeast storm accompanied by the highest tides since 1851.

(b) Wave action occurred along the entire shore from Black's Creek to Squantum. The bank immediately north of Black's Creek to the sea-wall, protected by riprap, was eroded above the riprap. Along the sea-wall there were eight points at which the sea-wall was undermined and the backfill washed out for distances up to 125 feet in length. The Metropolitan District Commission, which has jurisdiction over this beach, immediately started to backfill the washouts to prevent further damage to the wall. The beach at the curve of the wall beyond the pier at the Squantum Yacht Club was depleted and its elevation lowered. The bank north of the sea-wall was eroded back to the sidewalk in several places.

(c) The water at high tide came over the top of the bank and sea-wall, washing over the parking area and road adjacent to the beach, and flooding the summer and year-round houses built beyond the road. The parking area in most places was washed out, necessitating the placement of considerable fill to bring it back to its former condition. Sand, rock and debris were piled

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on the road and were moved off the traveled way by means of a snow-plow. The road was closed to traffic during high water on the 21st. The estimated damage was \$15,000."

29. The following report of the effects of the storm of November 28-30, 1945 was prepared by the U. S. Engineer Office, Boston, and is based upon press reports and field inspection. This storm was 53 hours in duration and the wind attained a maximum velocity of 68 m.p.h. The storm came at a neap range of tides in which predicted tides at Boston, Massachusetts, were from 8.4 to 8.9 feet. The recorded tides in Boston were 9.1 to 12.5 feet, which approached and exceeded maximum normal tides. This storm caused extensive damage all along the coast.

"The Quincy Shore area at the head of Quincy Bay suffered from wave attack all along the Shore Drive. This drive is protected partially by riprap and partially by a low stepped concrete sea-wall. At the south end of the beach the bank was cut back for a distance of 2 feet behind the riprap, and the riprap was displaced. At the south end of the stepped sea-wall, the waves washed over the wall and the street and washed out the sidewalks on the far side of the road for a distance of about 500 feet, (See Figure C-4). The sidewalks were built on an embankment 4 feet higher than the adjoining land. The houses adjacent to the walk are built on posts and have bridges connecting them to the walks. These bridges were destroyed. The sea-wall suffered damage, particularly at the manholes to the conduits which drained the low area behind the road. The wall was cracked and the buttresses were broken down. The beach elevation was lowered about one foot in the central section of the beach and stones replaced sand. A heavy barrier of sand was piled between the two yacht club piers in the center of the beach. The mouth of Sachem Creek was almost closed. The parking area in back of the wall was washed out for a depth of 1 to 2 feet and the road was covered with high piles of drift wood and sand. Just north of the yacht clubs, a new tide gate was being constructed to drain low areas behind the Shore Drive. The high seas flooded a large residential area bounded by Milton Road, Sharon Road and Colby Road, (See Figure C-5). These roads were under 5 to 8 feet of water and thirty-two (32) families were evacuated from their homes, many by boat. Beyond the northern end of the sea-wall, the coastal cliff was cut back 3 to 5 feet and riprap was displaced."

A local resident in the flooded area stated that the flood was the worst in 12 years and was two feet higher than a flood which resulted from the storm of April 19, 1940. Waves at the sea-wall shot spray 30 to 40 feet into the air.

30. Quincy shore was battered by three northeast storms in the fall and winter of 1947. These storms resulted in damage to the sea-wall, flooding of the highway, and flooding of lowlands adjacent to the highway.

a. On October 31, 1947, the attacking storm carried the high water from a predicted tide of 10.8 feet to 12.5 feet. Large timbers were hurled against the wall and yacht club, and were strewn over the highway. Landing floats were torn loose from the yacht club and destroyed against the wall, as was a 31-foot boat. Highway embankments were eroded and large washouts occurred in both parking areas and in sidewalks, the walks being on the landward side of the highway.

b. On November 12, 1947, a northeast storm, accompanied by 55-mile per hour winds and 79-mile per hour gusts, drove storm water over the sea-wall and boulevard and into the low areas. The highway was closed to traffic. Between 20 to 30 tons of debris were later removed from East Squantum Street, a causeway leading to Squantum.

c. On December 26, 1947, a northeast storm, accompanied by 43-mile per hour winds, washed high waters over the sea-wall stranding automobiles and flooding low residential areas.

These storms have resulted in considerable damage to an already weakened sea-wall, extensive erosion of highway shoulders, and destruction of parking area pavements. Numerous washouts have occurred in the parking areas. South of the National Sailors' Home sea-wall the embankment was cut back 5 to 10 feet, reaching the highway pavement in places. The riprap was left lying on the beach seaward of the embankment slope. The flooding of the lowlands during the cold months resulted in hardship for local residents, particularly through damage to home heating systems.

V. CHANGES IN BEACH AND OFFSHORE AREAS

31. Changes in Shore Lines. - (a) General. - Plate C-2 shows a plot of comparative shore lines in the Quincy Bay area developed from surveys made in 1847, 1892 and 1944 by the U. S. Coast and Geodetic Survey and in 1946 by the District Engineer. The 1944 shore line was obtained by aerial photographic methods. The available data did not permit the plotting of mean low water lines except for 1946. Prior to the construction of the coastal boulevard in 1905, the shore line of the study area was poorly defined by extensive marshlands which generally separated the uplands from the water. The highway construction across the marshlands greatly modified the coastline. The changes reflected by the positions of the 1892 and the 1944 and 1946 shore lines, therefore, are artificial and offer no indication of the natural changes taking place in the study area.

(b) Natural Changes in Shore Lines. - A comparison of the 1847 and 1892 shore lines indicates the trend of natural changes which were in effect prior to the construction of the highway. In the area of Profile A-3, there was a recession of approximately 100 feet in the shore line while between Profiles D and K there was a recession of approximately 400 feet along the ocean side of the marshlands. During the period there was also a southeasterly movement of the tidal creeks. The channel of the creek at Profile A-1 swung so as to have a northeast to southwest axis in lieu of an east to west axis. The mouth of Black's Creek at Profile C moved about 200 feet southeasterly. Accretion on the northwest bank of Black's Creek and erosion of the southeast bank moved the centerline of the creek 100 to 200 feet southeast. During the 47-year period a new inlet at Profile G was opened to the lagoon in back of the marshlands. This inlet was marked by two spits, the southeasterly one being recurved toward the south. The above discussed effects indicate that the natural shore line changes in the area,

prior to the construction of the highway, were the inundation of marshlands and the southeasterly migration of inlets.

32. Profiles. - (a) Surveys made along the beach prior to 1946 were not of sufficient detail to develop comparative profiles for a study of volumetric changes and changes in beach elevations. Table A as given below was prepared to indicate general changes in backshore areas and is based upon interpolation of elevations shown on plans prepared for the construction of the highway in 1905 and the construction of the sea-wall in 1926. The details of the 1905 and 1926 plans are such that the interpolated elevation must necessarily be considered an approximate elevation indicative of the general elevations of the profile area. The comparison of the 1905 and 1926 elevations indicates the extent of changes due to the construction of the stepped sea-wall. It must be noted that in each case, the unprotected beach was also subject to sea action for a 20-year period between surveys.

TABLE A - CHANGES IN BEACH ELEVATION

(Elevations Refer to Mean Low Water)

Profile	Back Edge of Wall			Front Edge of Wall			Thirty Feet Out		
	1905	1926	1946	1905	1926	1946	1905	1926	1946
A-3	8.0	-	13.8	7.8	11.8	11.5	-	-	10.5
A-2	9.1	11.7	14.0	9.0	9.2	12.4	8.7	8.3	10.2
A-1	8.2	11.7	14.0	7.2	-	10.0	3.3	7.9	7.3
A	8.2	11.0	13.4	8.2	10.3	5.7	8.7	-	3.3
B	9.7	12.0	13.0	8.6	10.8	8.4	6.8	-	7.0
C	Sachem Creek								
D	11.4	15.5	15.4	12.0	14.0	12.1	11.6	12.7	11.8
E	6.5	14.3	15.5	6.1	12.3	10.8	5.3	10.6	9.7
F	5.4	12.5	15.0	5.3	11.1	10.9	5.2	9.4	9.5
G	6.6	13.2	15.1	6.4	11.3	8.5	5.9	10.3	7.3
H	5.5	11.5	15.0	5.4	11.0	7.1	5.3	8.2	5.3
I	12.1	14.2	15.0	11.2	13.6	8.2	11.2	11.5	6.0

Elevation for years 1905 and 1926 based on surveys made prior to construction of highway embankment in 1905 and prior to construction of sea-wall in 1926. Elevations for 1946 are from actual survey of profile. The elevations of "Back edge of sea-wall" for 1905 are natural elevations and for 1926 and 1946 are elevations resulting from artificial fill.

(b) The elevations along the back edge of the sea-wall show that the present highway fill is from 4 to 6 feet above the original beach north of Profile D and from 8.5 to 9.5 feet above the original beach between Profiles E and H. Profile I, which crosses a hummock, indicates a change of only 3 feet. Old surveys indicate that between Profiles I and J, the hummock has been cut down as much as 13.5 feet for highway construction purposes.

(c) The elevations along the front edge of the wall indicate that beach elevations were generally 2 to 6 feet higher in 1926 than in 1905, which change is due to the highway embankment being constructed with a seaward slope of 1 on 10. Between 1926 and 1946 there has been erosion along the front of the sea-wall except at the north end where the beach was stable or building up, (Profiles A-3 and A-2). The erosion along the balance of the beach varied between 1.5 and 5.4 feet, with profile F remaining relatively stable with an erosion of only 0.2 feet. This general erosion may be properly taken as a result of the sea-wall construction. At two locations, Profiles A and I, the beach elevation is lower in 1946 than it was in 1905.

(d) The beach elevations taken at a point about 30 feet seaward of the front of the sea-wall indicate that there was accretion varying up to 5.0 feet between 1905 and 1926 along the beach. This accretion was probably due to the flat slope of seaward face of highway embankment extending into the area and the redistribution of fill materials by wave action. Between 1926 and 1946 both erosion and accretion were effected indicating a redistribution of materials without any regular pattern.

33. Offshore Depth Curves. - (a) General. - A comparative plot of offshore depths is shown on Plate C-2. These curves were developed from original surveys made by the U. S. Coast and Geodetic Survey between 1846 and 1853 and in 1892. Profiles surveyed for this study did not generally reach the 6-foot contour because of the very flat offshore slope, varying from 1/180 to 1/520 between mean low water and the 4-foot depth curve. Hence, development of comparative curves for the 1946 survey was not possible. Indication is made on each profile where the 6-foot depth was encountered.

(b) Changes at the 6-foot Depth Curve. - There was general erosion along the 6-foot depth curve between 1846 and 1892 resulting in landward movements varying up to 1200 feet. During this period the channel leading from Sachem Creek migrated about 1500 feet northwest. This migration aligned the centerline of the channel with the centerline of the main 12-foot channel leading into the bay. This 6-foot channel subsequent to 1912 was dredged a number of times along an alignment approximately on Profile C, as discussed in Paragraph 18, for depths varying from 6 to 8 feet. The channel has repeatedly filled in. The latest dredging of this channel was accomplished since the study survey was completed, to provide a channel 6 feet deep leading to a point about 250 feet from the yacht clubs, and a mooring basin 8 feet deep in front of the clubs. Profiles A, D, J and K crossed the 6-foot depth curves when surveyed in 1946. The position of these crossings indicate that between 1892 and 1946 the 6-foot depth curve moved about 400 feet landward.

(c) Changes at the 12 and 18-foot Depth Curves. - The configuration of the 12-foot contour indicates that it follows natural channels into the bay, one short channel branching southerly from a point off of Profile K and one long channel branching westerly from the same point. Between 1846 and 1892 these two channels extended themselves into the bay for about 500 feet, with the main westerly channel moving about 200 feet south in its alignment. The extension of the 12-foot channels into the bay was accompanied by the deepening of the channels to the extent that 18-foot depths were obtained within the channels in 1892.

(d) General Movements. - The movements of the offshore contours indicate a general trend for a greater depth of water to approach the shoreline and for a deep channel to maintain itself into the northwest part of the bay.

34. Littoral Drift. - (a) Littoral drift has never been a great factor along Quincy Shore and there is not much evidence that important movement of materials are effected along the beach. The beach lies at the head of Quincy Bay, almost directly southwest of the main entrance to Boston Harbor. This location places the shore directly in line with the dominant northeast winds which act on the coast and with the waves generated by such winds. The many islands, shoals and channels within the harbor, however, refract and diminish the waves to such an extent that except during storms, the currents acting on the beach are generally weak and ineffective. The currents through the channels between the islands are of a complex pattern, reversing themselves with the inflow and outflow of the tide in Boston Harbor.

(b) Prior to the construction of the coastal highway in 1905, the shore was generally marshland with the exception of the area immediately southeast of Profiles J and K where the only beach along Quincy Shore was located. This beach was built by the southeasterly drifting of materials eroded from a wave cut hummock. There were other sources of beach building materials in the area, but the currents and waves were too weak to reach them. The comparison of the 1846 and 1892 shore lines and offshore curves indicate that tidal creeks entering the marshes tended to migrate toward the southeast while the main offshore channel entering the bay as defined by 6 and 12-foot depth curves, tended to migrate to the northwest end of the bay. The development of the single beach, the migration of the inlets and the movement of the channel suggests that the principal current entering the bay moved along Squantum and then southeasterly along Quincy Shore.

(c) The evidence presented by present day beach conditions indicate that since the highway was constructed the movement of currents vary in direction. South of Profiles J and K, it appears from shore line configuration that materials drift toward the southeast. North of these profiles

the dominant movement appears to be toward the northwest. At Sachem Creek at Profile C, a bar tends to close the creek's channel northward along the face of the wall. A new artificial channel has to periodically cut through the bar. The drainage structure at Profile A-1 is large enough to act as a groin, and since its construction the beach has become slightly higher on the southeast side than on the northwest side of the structure, a condition more evident since sand was spread on the beach in that area in 1948. The extreme northerly end of the ~~sea-wall~~ is partially buried in sand, a condition obtaining prior to the spreading of sand in 1948, whereas the rest of the beach fronting the wall is below the top of the toe wall and is generally of coarse sand and gravel. It has been reported that in the last 10 years the beach northerly of Profile A-3 has become sandy and its use as a bathing area has been greatly increased. The dredged channel leading to the yacht clubs probably has affected the current flowing through the principal offshore channel, bringing deep water near the shore in the central part of the study area.

(d) The ~~sea-walls~~ and riprap revetments along the seaward side of the highway have sealed off all natural sources of beach building materials which might have been acted on by littoral currents. The present beach fronting the shore protection works is the result of the rearrangement of the materials which composed the former beach south of Profiles J and K and of the materials deposited in the area during highway embankment construction. These latter materials probably comprise the greatest amount of the beach materials.

(e) Littoral currents did not develop the beach, its existence being the result of man's construction activities. Existing beach conditions do not indicate any great movement of materials along the shore except at

Sachem Creek where the bar tends to turn the channel northward. The process in this area is not appreciably rapid except at times of great storms during which high water allows effective wave action to reach the sea-wall. It is concluded that littoral currents are not an important factor in the development or maintenance of this beach and that they are reversed in direction at various sections of the beach.

VI. EXISTING PROTECTIVE STRUCTURES
(Plate C-1)

35. Quincy Shore Drive. - a. - Prior to the construction of Quincy Shore Drive, the shore at the head of Quincy Bay was very irregular, being cut by tidal inlets and marshes. In 1905, the construction of the road, which was principally an embankment over the marshes and beach, sealed off the marshlands and low lying areas from the sea and realigned the shore of the bay to present a smooth contour. The embankment was located near the mean high water line and in some sections it was seaward of the high water line. The top of the roadway had a project elevation of 15.19 feet above mean low water north of Sachem Creek and 16.19 feet south of the creek. The embankment served as a dike to prevent wave attack on the adjacent coast. The embankment had a seaward slope of 10 to 1 and was not provided with any armor to resist waves. Bridges, culverts and drains constructed with the highway provided the initial control of creeks flowing into Quincy Bay. Wollaston Yacht Club, constructed about 1900, and Squantum Yacht Club, constructed about 1870, were not disturbed.

b. - The original roadway was 24 feet wide. In 1927, the width of the roadway was increased to 40 feet by placing additional fill on the seaward face of the embankment. In the study area, Profiles A-3 to I, the embankment was further increased to provide a 20-foot wide parking area and a stepped sea-wall was constructed in front of the parking area.

36. Vertical Faced Sea-walls. - a. - The original construction of shore protection in Quincy Bay was accomplished in 1910 when two walls were constructed, one at National Sailor's Home Hill (Profile I to J area) and one at Rufe's Hummock (about 500' south of Profile K).* These two walls

*Rufe's Hummock, as used herein, refers to the hummock so designated as plans prepared by the Metropolitan District Commission.

were constructed of mass concrete with a top width of 1 foot at Elevation 17.2 above mean low water, a base width of 3 feet at elevation 11.2, and a vertical seaward face. A cut-off wall 1 foot wide, extended 3 feet below the bottom of the walls. A small amount of riprap has been placed in front of Rufe's Hummock but it has not suffered any apparent damage since its erection and does protect the fill behind it.

b. The sea-wall at Sailor's Home Hill, See Figure C-4 in the Profile J area, has suffered damage from time to time. Most of the damage has been in the form of spalling of concrete on its face, though the northerly end of the wall was damaged to such an extent that 50 feet of it had to be replaced. The height of the wall above mean low water was raised from elevation 17.2 to 18.4 in 1929, by increasing the height of the coping. The survey of 1946 showed the top of the wall to be at elevation 18.2. The base of the wall has been repaired and is in generally good condition though there are several small holes near its base that need filling. In 1943, the northerly 50 feet of the wall was entirely reconstructed of reinforced concrete. The new section was cast as a monolith, comprising a 1 foot thick coping, extending 1-1/2 feet above the wall proper to elevation 18.44, a wall section varying from 2 to 3 feet in thickness and a heel 3 feet wide and 3 feet thick. The bottom of the wall and heel was at elevation 5.2, below which, a five-foot wooden out-off wall was provided. The area behind the wall is used for parking of automobiles. The wall has withstood severe wave action during its life but has not prevented washouts occurring in the fill behind it. There is a constant need of filling washouts in the area after reoccurring storms. There has been apparent erosion of the fronting beach since a toe wall has been constructed at its base. The beach fronting the wall is coarse sand and from 6 to 8 feet below the top of the wall. The sand tends to fill voids between the riprap.

c. The embankment in Profile K area between the two sea-walls has been protected by riprap consisting of 3 to 5 cubic foot stones placed from beach level to the top of the embankment. The riprap has not been successful and has been displaced to beach levels by erosion of the bank for depths up to 3 feet. The displaced riprap has been replaced with additional stone. Washouts occur behind the riprap at all locations along the entire beach during storms and are refilled as soon as practical. The beach at Profile K is composed of small stones.

37. Stepped Sea-Wall. - (See Figures C-1, C-2 and C-3) a. - The concrete stepped sea-wall was constructed between Profiles A-3 and I in 1926 for a distance of approximately 5675 feet. The wall comprises two units acting as a single structure. The lower unit is a sloping face, gravity type toe wall, 6 feet high, having a top width of 2 feet and a bottom width of 3-1/2 feet. The project elevation of the top of the toe wall is 11.2 feet above mean low water north of Sachem Creek and 12.2 feet above mean low water south of Sachem Creek. A timber out-off wall is provided below the concrete toe wall. The upper unit is a reinforced concrete slab, cast to form two steps and a curb above the upper step. The slab originally rested on fill placed behind the toe wall. The project elevation of the top of the curb wall is 15.2 feet above mean low water north of Sachem Creek and 16.2 feet above mean low water south of Sachem Creek. Expansion joints were provided every 25 feet in the stepped slab, the slabs having curbs 1-1/2 feet wide cast in them to lap the joint and act as buttresses. The toe of slabs rest in a seat at the top of the back of the toe wall and the buttresses extend across the top of the toe wall. A concrete ramp, 10 feet wide, is provided every 1000 feet along the wall. The ramps have a maximum elevation one foot lower than the top of the curb wall. Openings 6 feet wide and 1 foot deep were also provided every 75 to 100 feet along the top of the wall.

b. - This wall has been subject to constant and recurring damage from wave action and has been repaired a number of times. In 1929 the height of the wall, for a distance of 40 feet on either side of Sachem Creek, was raised to meet the elevation of the bridge over the creek, which is 17.5 feet above mean low water. This was effected by casting a reinforced concrete section on the top of the existing stepped wall. In 1937, extensive repairs were made to the wall between Profiles A-1 and B, with 425 feet of the stepped unit being reconstructed. The reconstructed steps were modified in design to provide a butt connection in lieu of a lap connection at expansion joints. The buttresses at the butt joints had a total width of 16 inches. The buttresses were cut off at the base of the steps and did not extend over the toe wall as in the original design. A timber plank cut off was provided under the back of the stepped unit. Original construction provided a cutoff only under the toe wall. Reinforcing steel was added to the top of the steps while original construction provided steel only in the base of the slab. The existing step unit was also restored for a total distance of 530 feet.

c. - The 530 feet of steps which were restored in 1937 were reconstructed in 1938. The design of the reconstructed steps was similar to that used in 1937 except that reinforcing steel was added to the buttresses at the expansion joints.

d. - In 1943 the southerly 200 feet of the sea-wall was rebuilt in conjunction with the rebuilding of a part of the adjoining vertical face wall. Here again only the stepped portion of the wall was replaced. The details used were similar to those used in the 1938 reconstruction of other wall sections.

e. - In 1945, 800 feet of the stepped unit of the wall was replaced immediately north and adjacent to the section rebuilt in 1943, see Figure C-3. A 75-foot section of the stepped unit of the wall was also

rebuilt in 1945 adjacent to Profile A-1. The section used was similar to that used in the 1943 reconstruction of walls.

f. - (1) The sea-wall has been only moderately successful in protecting the coast-line. Due to its low elevations, varying in 1946 from 14.3 to 16.3 feet above mean low water, it has not prevented the flooding of the highway and lowlands beyond the highway. It is to be noted that the low elevations of the top of the wall are reduced by 1 foot every 75 to 100 feet by the 6-foot openings spaced 75 to 100 feet in the curb along the top of the wall. The highway is often impassable to traffic during storms and twice in the past six years extensive flooding of low residential areas has occurred. There have been continuous washouts behind the sea-wall and at times of serious flooding the landward side of the highway has been washed out. There is no record of the highway having been completely washed out.

(2) No attempt was made to build a beach in front of the wall at the time of its construction. The wall, in places, was set in back of the face of embankment thus requiring some excavation seaward of the wall. The disposition of this material is not known but it is assumed it was used for fill. The beach apparently has built up in front of some sections of the wall. However, there has been greater erosion in other locations which has resulted in the undermining of the wall. It has been noted in the field that in the area between Profiles C and E a gully tends to form at the base of the sea-wall.

(3) The sea-wall has been subject to continuous serious damage. There has been an extensive replacement of the upper stepped unit through a period of years, but there has been no replacement of the lower toe wall unit although it was severely damaged. Both units of the sea-wall are today in a very poor state. In the upper stepped section the buttresses at the expansion joints are cracked and broken off at all locations along the beach;

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the steps are broken and spalled; and sections of the steps which were rebuilt in 1945 are completely undermined. In the lower toe wall unit, the expansion joints generally show disintegration; there are large holes spalled in the surface of the wall at all sections and in the area of Profiles A-1 to B there are holes large enough for a man to crawl through. At the north and south ends of the beach the wall is undermined and the bottom is disintegrating. (See Figures C-1 and C-3). In several places the toe wall is tipped forward to open the joint between the toe wall and the stepped wall, and in other areas there are large chunks of concrete broken off of the top of the toe wall. This damage appears to be, in part, due to a poor design for a wall subject to wave action. The waves break diagonally against the wall and run along the stepped unit to batter the narrow buttresses, which action results in the breaking off of the buttresses and the opening of construction joints for further damage from wave action. The beach fronting this sea-wall is of coarse sand and gravel for a width of approximately 100 feet and then mud to mean low water. The mean low water line is from 250 to 1000 feet from the sea-wall. The sand and gravel beach has developed naturally in its present position since the construction of the wall and the adjacent highway.

38. Parapet Wall. - (See Figure C-1). In the winter of 1948 a reinforced concrete parapet was added to the top of the northerly 1130 feet of the existing stepped sea-wall, between Profile A-3 and a point about 75 feet southerly at Profile A. The parapet is 3 feet 3 inches wide and 4 feet high with a top elevation 19.19 feet above mean low water. The inner 2 feet of the parapet rests on the ground, and extends 2.5 feet below the original surface of the parking area and 4.0 feet below the regraded surface. Access to the beach is provided at the foot of Appleton Street and Bayfield Street by steps which pass over the top of the wall, the steps are set at right angles to the wall and extend across the parking

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area to within 8 feet of the highway. The parapet is constructed in the only area where there has been appreciable accretion and the base of the stepped wall is protected by the beach. The increased height afforded by the parapet has stopped wave wash from reaching the highway during normal storm periods, a condition prevailing elsewhere along the stepped seawall. Since the ends of the parapet are not tied to high ground it will not prevent flooding during major storms and extreme high waters.

39. Sachem Creek. - (See Figure C-2). The first control of Sachem Creek at Profile C was accomplished in 1904 at the time of the initial highway construction when a concrete bridge, having a clear span of 20 feet, was constructed over the river. Each abutment of the bridge was supported on wood piles. In 1926 the bridge was increased 20 feet in width by building up the seaward sides of the original stepped abutment. Wing walls were constructed on either side of the bridge for a distance of 32 feet from the centerline. The wing walls present a vertical face to the sea and have a top elevation of 18.9 feet above mean low water. The creek today is totally enclosed in a 60-inch concrete pipe for a distance of approximately one mile inland from tide gates located immediately adjacent to the landward side of the bridge. The bridge fixes the location of the creek's discharge onto the beach. A sand and gravel bar tends to build across the front of the bridge and to turn the discharge channel northerly along the face of the adjacent seawall. An artificial channel is periodically dug across the bar. The edge of the northerly half of the bridge deck slab and the northerly abutment have been damaged by flow of debris under the bridge.

40. Creek at Profile F. - The creek at Profile F drains a low area adjacent to the shore drive. The first stabilization of this creek was accomplished in 1905, by the construction of a 6 foot square, open concrete box culvert passing under the road. In 1911 tide gates were constructed

at the seaward end of the culvert and the discharge confined in two 24-inch cast iron pipes supported on piles and extending 70 feet onto the beach, with flap valves at the outer end. The tide gate chambers were incorporated in the stepped sea-wall when it was constructed in 1926. The pipes were extended 108 feet seaward in 1947 to eliminate the drainage channel across the beach which had to be dug out daily.

41. Stream near Profile A-1. - The original control of the stream near Profile A-1 was accomplished in 1905 by means of two 24-inch box culverts. In 1926 this control was changed to an 18-inch pipe drain. In 1945 this 18-inch pipe drain was abandoned and a 36-inch pipe drain was constructed in which the flow is controlled by a tide gate on the land side of the highway and a flap valve at the outer end of the pipe. The drain is protected by a 6-foot square concrete encasement, supported on piles, which projects approximately 100 feet onto the beach and has a top elevation five feet above the beach at its outer end. This drain is shown in the upper picture in Figure C-1. This structure acts as a sand catcher and it has been noted that sand has built up several inches higher on its south side than on its north side.

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VII. PLANS OF PROTECTION
(Plate C-3)

42. Analysis of Principal Features of Problems. - a. - The present beach along Quincy shore is artificially developed, resulting from the realignment of the shores of Quincy Bay through the construction of a highway over the beaches and marshes formerly comprising the shore line. The highway is generally built on an embankment and its project center-line elevation is 15.2 feet above mean low water northerly of Sachem Creek at Profile C and 16.2 southerly of the Creek. The seaward face of the embankment is protected by sea-walls and riprap. Within the study area, between Profiles A-3 and I, there is a low concrete, stepped sea-wall whose top elevations vary from 14.3 to 16.3 feet above mean low water. This sea-wall is subject to constant damage due to wave action and though rebuilt a number of times, still requires extensive reconstruction. This sea-wall is too low to provide adequate protection to the highway and adjacent residences. A four foot high parapet has been added to the northerly 1130 feet of the stepped wall, but it will not protect the area from high waters since it is not tied to high ground. There is a vertical faced sea-wall in Profile J area which has a top elevation of 18.2 feet above mean low water. This vertical wall is in a state of minor disrepair and is overtopped with wave wash at extreme high storm waters. In the Profile K area, the highway embankment has been protected by riprap which is subject to displacement through erosion of the embankment. The overtopping of these protective structures results in the erosion of fill behind the wall, the flooding of a principal highway and the flooding of densely populated residential areas. The wave wash blown onto the road during minor storms creates a very serious traffic condition on the very heavily travelled highway. The usable beach fronting the sea-walls is very narrow and consists of coarse sand and gravel.

b. - The beach is contiguous to a densely populated section and free public parking is provided along the entire length of the shore. Due to its convenient location and the available parking area the beach is used extensively for bathing. This use coupled with the narrowness of the usable beach area results in its being overcrowded during the height of the season.

c. - A bar forms in front of the Sachem Creek Bridge, partially closing the discharge channel and turning it northerly along the face of the adjacent sea-wall. A channel has to be periodically dug across the bar. The beach in front of most sections of the wall is eroding and the walls in places are being undermined.

43. Objectives of Study. - The cooperating agency's objective in this study is the determination of the best method of preventing further erosion, stabilizing and improving the beaches, and protecting the sea-walls.

44. Improvement Desired by Local Interests. - a. - Local interests desire a sandy beach at Quincy Shore. A bill, House No. 529 (1947) was introduced in 1947 to the Massachusetts General Court, authorizing and directing the Metropolitan District Commission to improve and sand the beach. This bill was referred to the next annual session of the General Court and was passed as House No. 311 (1948). This legislative action resulted in the spreading of sand as described in Paragraph 17.

b. - In December 1947, severe storms damaged Quincy Shore Drive and flooded adjacent low residential areas. As the result of this damage, and in order to prevent the overflow of seawaters, the local state representative, Mr. A. B. Keith, introduced a bill, House No. 596 (1948) in the Massachusetts General Court authorizing and directing repairs and additions to existing shore protective works between Squantum Yacht Club and East Squantum Street, which connects Squantum to the mainland. Passage of this bill resulted in the construction of the parapet wall described in Paragraph 38.

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45. Reconstruction of Existing Stepped Sea-wall. - In developing plans for achieving the objectives of this study, consideration was first given to the reconstruction of the existing stepped sea-wall. The present wall is only twenty-one years old and in this short time it has been extensively rebuilt on four occasions, the last time being in 1945. The wall today is in need of very extensive repairs, both to the upper stepped section and to the lower toe wall. In many places the wall is being undermined and requires deeper foundations and materials supporting the stepped section have been washed out. The wall is apparently too weak to withstand the forces attacking it and there is no assurance that it will remain in good condition if rebuilt.

46. The present stepped sea-wall, being in part below the maximum recorded high-water elevation, is too low to furnish proper protection to the property behind it. Reconstruction of the wall must include raising it to an elevation that will provide proper protection for adjacent areas. The top elevations of successful sea-walls on the islands in Boston Harbor are from 20 to 22 feet above mean low water, and such walls are in exposed positions near deep water. Quincy shore is adjacent to a very shoal area. A wall having a top elevation of 18 feet above mean low water will provide adequate protection for the area. This elevation is three feet above maximum recorded high water. Under most storm conditions it will provide for 5 to 6-foot storm waves above still water level.

47. During the period of study of this beach, The Metropolitan District Commission increased the height of the northerly 1130 feet of the stepped sea-wall by the addition of a 4-foot high parapet having a top elevation of 19.19 feet above mean low water. This parapet is constructed on the only section of the wall which is not endangered by an eroding beach and which is not in need of repairs. In order to be effective this parapet should be tied by a wall to high ground, about 450 feet northward at Hovey Street and should be extended to the high bridge at Sachem Creek about 1450 feet.

southerly. The wall immediately south of the parapet faces the area of greatest erosion along the beach, and is in the poorest state of repair. The toe wall section is severely damaged and undermined to such an extent that it appears to be all but demolished. The stepped section of the wall though presently in fair condition due to recent rebuilding is undermined, and in the past has required more rebuilding than other similar sections. The parapet cannot be further extended without reconstruction of the wall itself.

48. Patronage of the beach comprises principally two classes of people, local residents and autoists. It is necessary, in order to obtain maximum benefit to the public for its investment to maintain the public parking along the entire length of the beach. Cars park perpendicular to the stepped sea-wall, with their bumpers touching or overhanging the wall. Autoists then pass directly from their cars down the wall to the beach. There is no walk along the sea-wall and the parking area is not wide enough to accommodate such a walk under the present system of angle parking. The raising of the wall, as accomplished by the parapet, requires stairs located at intervals to pass people over the wall to the beach, and a walk behind the parapet to permit passage to the access steps. Vehicular traffic density on the highway prohibits any use of it by pedestrians or the widening of the parking area. The only way in which the necessary walk can be provided within the present parking area is to park the automobiles parallel to the wall, under which system parking space would be available for only 39 percent of the cars now accommodated. A 61 percent reduction of the only available parking space would seriously affect the patronage of the beach. Additional parking area could be provided through the development of the marshes at the base of Squantum and adjacent to Blacks Creek, which are flooded at extreme high water and would require a great amount of fill to develop them. Maintenance of existing parking areas is more desirable than the development of the

marsh areas, since such development would tend to concentrate crowds at each end of the beach in lieu of distributing them along the entire beach.

49. In view of the poor record of the stepped sea-wall in withstanding the attacking forces; the need of increasing its height to provide proper protection to adjacent areas; the need of developing new parking areas in the event that the height of the sea-wall is increased; and the need of very extensive reconstruction at all points along the wall; it is considered inadvisable to reconstruct the present wall or extend the parapet as the principal shore protection of the area, but to utilize it in its present condition as the core of another type of protection.

50. Plan of Improvement. - The plan of improvement was developed through the consideration of a number of methods of achieving the objectives of the study. The plan comprises:

a. - The construction of an artificial beach to protect the highway from direct wave attack and to provide an adequate recreation area.

b. - The construction of a bulkhead and sea-wall to prevent the wash of beach materials onto the road and to prevent the flooding of adjacent areas where existing structures on ground elevations are too low to prevent such action.

The construction of the artificial beach involves the extension of existing drains, the control of Sachem Creek, the construction of two groins to protect the dredged yacht basins and the tying of the parapet wall to high ground north of Profile A-3. The construction of the bulkhead involves the provision of a walk to allow passage to access stairs to the beach. This plan is discussed in the following paragraphs and the principal details are shown on Plate C-3.

51. Fill. - There are no known suitable materials in the area which may be placed by hydraulic methods and all fill must be transported to the

beach from suitable borrow pits, ten to twenty miles from the beach.

For economy, the fill has been designed to be constructed of two materials with the upper layer having a minimum thickness of three feet. The lower course of the fill consists of bank run sand and gravel screened once to remove sizes greater than two inches in diameter. The upper course is sand comparable to that existing at present on the beach

52. The fill has a top elevation of fifteen feet above mean low water at the wall and a uniform slope of 1 on 20 to the point of its intersection with the existing beach. The top elevation was selected as the highest level to which still water rises and the slope was selected through a study of existing beach profiles. The slope of 1 on 20 provides a dry beach 120 feet wide at mean high water and 60 feet wide at normal spring tide. This wide dry beach will serve to protect the sea-wall and bulkhead structures from wave attack during normal tidal conditions and to dissipate the waves during storm periods before they can attack the structures. The wide beach will also provide suitable recreational areas at all stages of the tide. The slope of the fill between the proposed groins will be steepened to 1 on 15 to prevent encroachment on the yacht clubs and their dredge mooring basin. This slope is flatter than the toe of the existing foreshore slope. The slope of 1 on 15 provides a dry beach 90 feet wide at mean high water and 45 feet wide at spring high water. The quantities involved in the proposed fill are 221,500 cubic yards of sand and 125,450 cubic yards of sand and gravel. The slopes selected for the fill and the materials selected for the surface course are both comparable to the slopes and materials that have occurred on the beach, and fill placed artificially, as proposed, will be stable and will not suffer rapid erosion.

53. Groins. - The presence of the two yacht clubs and their dredged mooring basin in the area, presents a special problem. Care must be taken to prevent creating any hazard to the yachts and to prevent the filling of

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their mooring basin with the artificial beach fill. As discussed in Paragraph 52, the slope of the artificial fill was steepened from 1 on 20 to 1 on 15 in the vicinity of the clubs to prevent encroachment on them and the basin. To maintain these slopes and to prevent the movement of materials into the yacht club area, two impermeable stone groins have been provided at the points of change in beach slopes. These groins are each 200 feet from the adjacent clubhouse. The groins are 350 feet long with their outer ends extending 70 to 80 feet beyond the toe of slope of the fill, and are of sufficient height to prevent materials going over their tops. The ends of the groins will be submerged at high water, and are provided with navigation markers.

54. Control of Sachem Creek. - Sachem Creek is to be confined in a 60-inch pipe culvert extending across the beach to a point seaward of the toe of slope of the artificial fill. The size of pipe selected is the same as that used to enclose the creek landward of the highway bridge. The pipe line extends across an old marsh area, and requires support for its entire length by a cradle resting on piles. A tide flap controls the flow at the seaward end of the line. The landward end of the proposed pipe line terminates at a concrete bulkhead constructed to seal the bridge opening. This construction will allow the drainage from both the confined Sachem Creek and the adjacent lowlands to flow into the new pipe culvert, and will prevent high tidal waters from flooding the lowlands.

55. Existing Drains. - Outfalls of several storm water drains exist on the beach. The proposed fill will cover these structures requiring their extension to points beyond the proposed fill. These drains comprise:

- a. - Two cast iron pipes near Profile F.
- b. - Tile pipe near Profile A.
- c. - Concrete encased pipe near Profile A-1.
- d. - Concrete pipe near Profile A-3.

It is assumed that the extensions will be made in the same manner as the original construction.

56. Bulkhead. - A bulkhead having a top elevation 18 feet above mean low water is to be constructed in the low area lying between the end of the parapet near Hollis Avenue and the National Sailor's Home Hill. The northerly end will tie into the parapet and the southerly end will terminate at the sea-wall near Profile I. The bulkhead is designed to prevent wave uprush from washing beach materials onto the highway and to prevent extremely high storm waves from washing over the highway and onto adjacent lowlands, and is similar to successful structures at Roughan's Point, Revere, Massachusetts and at Hampton Beach, New Hampshire which are located in very exposed positions.

57. The bulkhead consists of a steel sheet-pile core encased in reinforced concrete above beach levels. The piling is located close to the face of the existing stepped wall, with the base of the piling being driven to elevation 0.0. The present sea-wall structure relieves the bulkhead of thrust loads from the highway embankment, and, conversely, forms a backing for the bulkhead in the event that the beach becomes eroded.

58. Passage over or through the bulkhead is to be provided for people using the beach and yacht clubs, yachts being launched at the beach, and maintenance equipment working on the beach. At intervals of approximately 800 feet, bastions project seaward to allow the construction of steps from sidewalk level to the top of the wall and thence down the face of the wall a sufficient depth to allow easy access to the beach, under varying beach elevations. Passage to the yacht clubs is provided by two bastions with steps from sidewalk level to the level of the deck of the wood piers. This bastion construction maintains the full bulkhead height at all points in order that yachts may be launched at the clubs and maintenance equipment driven onto the beach, gates are provided in the bulkhead at four locations which are to be sealed at all times by stop logs locked in place, except when the gates are in actual use.

59. Walk. - A walk is to be constructed behind the bulkhead to provide passage from parked automobiles to the back access stairs. The walk consists of compacted sand and gravel fill placed over the existing stepped sea-wall to curb level and sealed with asphalt pavement. The 6-foot openings which occur every 75 to 100 feet along the curb are to be filled with concrete. The walk also provides a promenade along the entire beach, and will extend the general public's use of the beach beyond the bathing season.

60. Concrete Sea-wall. - A concrete sea-wall is to be constructed between the northerly end of the existing parapet at Profile A-3 and high ground at Billings Street, about 325 feet northerly to provide the same protection northerly of the parapet as will be afforded by the bulkhead to the south. The wall is a concrete structure having the same top elevation, 19.2 feet above mean low water and width, 3 feet 3 inches, as the existing parapet so as to appear continuous with the parapet. Bottom elevation will vary with ground elevation as the wall approaches high ground. A steel pile cut-off wall is provided below the wall as protection against future undermining.

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VIII. ECONOMIC ANALYSIS

61. Basis of Analysis. - a. Estimates of first cost for the plan of improvement and protection are given in Appendix II and summarized in Paragraph 62.

b. An estimate of annual benefits to be derived from the recommended improvement is given in Appendix III and summarized in Paragraph 63.

62. Estimate of First Cost. - The total first cost of the work is estimated as \$849,000, as summarized below:

Fill	\$502,350
Groins	15,391
Bulkhead	174,266
Walk	15,950
Concrete Sea-wall	8,486
Drains & Sachem Creek Culvert	<u>22,480</u>
	\$738,923
Engineering and Con- tingencies	<u>110,077</u>
Total First Cost	\$849,000

63. Estimates of Benefits. - a. General. - The benefits to be derived from the recommended improvement of Quincy shore are; the prevention of direct damages, the prevention of indirect damages, the increase of land and property values, the increase of recreational facilities, the protection of yacht club structures and interests, and the improvement of traffic conditions on the Shore Drive.

b. Average Annual Direct Damages Prevented. - From surveys of storm damages, analysis of storm frequency and records of the Metropolitan District Commission, the estimated average annual expenditures to repair

direct damages over the period of record have been:

Federal	\$	0
Non-Federal Public		11,850
Private		<u>0</u>
Total	\$	11,850

The above annual damages prevented include funds expended in direct repair of damages and the annual charges on the amount of money presently required to repair the existing severely damaged stepped sea-wall. This latter expenditure will not be necessary if the proposed plan of improvement is adopted.

c. Indirect Damages Prevented. - (1) Indirect losses at Quincy Shore result from the interruption of traffic, the interruption of business, the flooding of low residential areas, and the disruption of general activities in the area. The shore drive is used as the principal traffic artery from Boston to cities and towns south of Boston and the resort areas on the south shore of Massachusetts Bay and on Cape Cod. There are several other routes available but such routes pass through business sections of Quincy and carry slower moving traffic, and the transfer of traffic to such routes results in traffic congestion. In view of the thousands of commuters who utilize the shore drive to and from work each day, any detour of traffic results in a great loss of time and disruption of the commuters' work and business.

(2) Business establishments along the shore drive are of two classes; refreshment stands, principally serving beach patrons in the summer, and filling stations, bowling alleys, stores, restaurants and cocktail lounges, serving autoists and beach patrons the year round. Any interruption of traffic seriously affects the business of the latter group.

(3) Low lying residential areas are often seriously flooded by waters passing over the driveway. At such times people are evacuated by boats, their homes flooded and the roads and lawns washed out. Estimate of damages to roads and buildings for one storm in 1945 is \$20,000 to \$25,000, exclusive of the loss of personal effects, contents of the buildings and damage to automobiles garaged in the area. A similar flood occurred five years previously. In the fall and winter of 1947 these areas suffered additional floodings. Winter flooding of the area endangers public health through the crippling of home heating systems.

(4) The recurring indirect damages sustained possess a monetary value of considerable importance to both local residents and to residents of adjacent communities.

(5) The intangible nature of the benefits which would result through the prevention of indirect losses does not allow a complete evaluation of such benefits. A partial evaluation has been made on the basis of average annual expenditures for repair of damage in the low residential areas which are flooded during storms. The two critical flood areas are bounded by (A) Hollis Avenue, Edwin Street, Faxon Road and Bayfield Street, and (B) by Sachem Street, Copley Street and Rice Road, as indicated on Figure C-5. The partially evaluated benefits are:

a. Federal	\$	0
b. Non-Federal Public		6,000
c. Private		<u>3,000</u>
Total	\$	9,000

d. Increased Earning Power of Property Resulting from Shore Protection. - All property adjacent to the proposed work will increase in value as the result of the greater degree of protection afforded it from wave attack by the high bulkhead and wide beach. Property now owned by the

Metropolitan District Commission will be retained in public ownership, and hence no return on its increased value can be realized. Therefore, no benefit is evaluated for the increased worth of public property. The benefit to privately owned property may be evaluated since such property is subject to resale, the evaluation being made in terms of interest at 3.5 percent on the increase in property valuation. Since certain areas are subject to greater storm attack than others, the increase in value due to protection from storm attack will vary. Accordingly, it is estimated that frontal property in the two critical flood areas, described in the preceding subparagraph will increase 60 percent in value, while the balance of frontal property will increase 10 percent in value. The proposed plan of shore protection will eliminate the flooding now experienced in the two critical areas. Accordingly, marginal property, property lying in the rear of frontal property, in the two critical flood areas will also increase in value. This increase is estimated to be 50 percent of assessed valuation. The annual benefits derived from increased property valuations due to shore protection are:

<u>a.</u> Federal	\$ 0
<u>b.</u> Non-Federal Public	18,910
<u>c.</u> Private	<u>17,410</u>
Total	\$ 36,320

e. Recreational Benefits. - (1) The accomplishment of the proposed plan of improvement will result in a sandy beach 8500 feet long and generally 120 feet wide at mean high water replacing the present narrow, stony and gravelly beach which is partially inundated at high water. Important recreational benefits to the general public and to private interests will result from the proposed beach which will accommodate 13,600 people without crowding, thus providing an adequate area for recreational

activity. Its location in a metropolitan residential area and its nearness and accessibility to other metropolitan populations will result in increased patronage, estimated to be four times the present average daily patronage. Property zoned for business will be more valuable because of the greater volume of business due to increased beach patronage and greater rental returns may be realized thereon. Residential property values will increase due to the nearness of a desirable beach, the increase being due to personal enjoyment of residents derived from the use of an improved beach and the opportunity to rent or sell property to those who seek seasonal or permanent residences adjacent to good beaches. The full monetary worth of adequate recreational facilities located but six miles from the center of a major city such as Boston cannot be evaluated. A partial evaluation of recreational benefits is as follows:

<u>a.</u> Federal	\$ 0
<u>b.</u> Non-Federal Public	35,250
<u>c.</u> Private	<u>21,600</u>
Total	\$ 56,850

(2) In addition to the public recreational benefit derived from beach improvement as discussed above, the public will realize an important benefit from the walk to be constructed in conjunction with the bulkhead. At present there is no walk immediately adjacent to the beach, and those desiring to enjoy a walk along the shore must stay on the sidewalk on the landward side of the shore drive, where their view is blocked four by lanes of moving traffic and a row of parked cars, and they must cross numerous busy side streets. The walk will provide a continuous, uninterrupted promenade adjacent to the beach for its entire length, an important asset to the public beach development and of direct benefit to the general public. Monetary evaluation of the benefit is not made.

f. Intangible Benefits. - The location of the Squantum and Wollaston Yacht Clubs and the dredged channel and mooring basin necessitated the introduction of two groins in the project design to prevent the movement of the artificial fill into the mooring basin and channel. Representatives of the yacht clubs, in reviewing the plan, have stated that the groins will improve mooring conditions for small boats and afford added protection to the clubs from storms. The groins will also serve as barriers, restraining bathers from the vicinity of the yacht clubs where drownings have occurred through bathers unknowingly moving into deep water in the dredged areas.

64. Federal, Non-Federal Public and Private Interest. - Federal interest in a shore protection project is defined as the benefit secured by the United States as a landowner. Non-Federal public interest is defined as (a) the benefits accruing to a state or political subdivision thereof as a landowner and (b) benefits accruing to the general public. Private interest is defined as the benefit derived by individuals or non-public groups of individuals on account of the ownership of lands and business enterprises. The total interest in a project is the summation of all benefits accruing thereunder.

a. Public Ownership. - (1) Federal. - The Federal Government owns no property at Quincy Shore.

(2) Non-Federal Public. - Non-Federal publicly owned property along Quincy Shore comprises land, sea-walls, parking area, road, sidewalks and a police and sanitary building. All public property is owned by the Metropolitan District. This public property has the following estimated valuation:

Land	\$ 7,500
Shore Protective Structures	500,000
Buildings	10,000
Roads	<u>130,000</u>
Total	\$647,500

b. Private Ownership. - (1) The assessed valuation of private property and tax income to the City of Quincy is as tabulated below. Frontal property is property adjacent to the shore drive. Marginal property is that lying between frontal property and the landward limit of the areas considered. The tabulation is set up to show total valuation and tax return for the entire area considered to be affected by the proposed improvement, and to show valuations and tax returns in two critical sub-areas which are subject to flooding from storm waves, all as indicated on Figure C-5.

(2) The assessed valuations and tax returns for the above areas are as follows based on the 1948 tax rate of \$38.00 per 1000 dollars of assessed valuation.

<u>Assessed Valuation</u>		<u>Annual Tax Return</u>
Total Area (including Critical Areas)		
Frontal Property	\$ 429,800	\$ 16,330
Marginal Property	<u>8,459,700</u>	<u>321,470</u>
Total	\$8,889,500	\$ 337,800
Critical Area A.		
Frontal Property	\$ 99,800	\$ 3,790
Marginal Property	<u>459,600</u>	<u>17,460</u>
Total	\$ 559,400	\$ 21,250
Critical Area B		
Frontal Property	\$ 24,600	\$ 930
Marginal Property	<u>796,700</u>	<u>30,270</u>
Total	\$ 821,300	\$ 31,200

(3) Present sales values of private property are estimated to be 50 percent above assessed valuations. Sales values are:

Total Area

Frontal Property	\$ 644,700
Marginal Property	<u>12,689,550</u>
Total	\$13,334,250

Critical Area A

Frontal Property	\$ 149,700
Marginal Property	<u>689,400</u>
Total	\$ 839,100

Critical Area B

Frontal Property	36,900
Marginal Property	<u>1,195,050</u>
Total	\$ 1,231,950

c. Lands, Easements and Rights-of-Way. - The improvement proposed herein is planned for construction on lands now publicly-owned.

d. Benefits and Interests. - The amount of the interest of one agency in a project is the percentage of that agency's benefits to accrue from the project. On the basis of benefits evaluated in Paragraph 63, the percentage of benefits derived by each agency is as follows:

<u>Agency</u>	<u>Annual Benefits</u>	<u>Percent of Interest</u>
<u>a.</u> Federal	\$ 0	0
<u>b.</u> Non-Federal Public	72,010	63
<u>c.</u> Private	<u>42,010</u>	<u>37</u>
Total	\$114,020	100

65. Allocation of Costs. - The basic policy for the allocation of costs is expressed in Public Law 727, 79th Congress, 2nd Session, which provides that the Federal Government may contribute a percentage, not to exceed 33-1/3 percent, of the total cost of construction of works for the improve-

ment and protection of shores owned by States, municipalities or other political subdivisions, excluding costs of necessary lands, easements and rights-of-way. The federal share of the cost of a project thus becomes the percentage of the total interest represented by the Federal interest plus a percentage of the cost of the non-Federal public interest as allowed under the law. The non-Federal share of the cost is represented by the non-Federal interest in the total interest less the Federal contribution allowed under the law.

66. Federal interest is shown in Paragraph 60 to be zero, Federal participation in the proposed plan of improvement, as determined in Paragraph 64, is one-third of the construction cost. The total Federal share of the cost of the proposed plan is thus one-third of the construction cost. The non-Federal share is two-thirds of the construction cost.

67. Annual Charges. (See Appendix II). - The estimated annual carrying charges for the plan of improvement as computed in Appendix II are \$45,750. The annual carrying charges have been based upon interest rates of 3 percent for federal cost, 3.5 percent for non-Federal cost, and amortization over a period of 40 years.

68. Justification of Project. - The ratio of evaluated benefits \$114,020, to annual costs, \$45,750 is 2.5 to 1. Of the benefits evaluated, 63 percent are public benefits. The effect upon the public welfare and health of the people of an improved beach in a densely populated metropolitan area is not susceptible to complete monetary evaluation. The nearness of the beach to the heart of Boston, the moderate cost of public transportation from all parts of the metropolitan area, the good roads and the parking facilities make this beach easily available to metropolitan populations. The proposed project transforms a presently inadequate beach to a dry beach generally 120 feet wide at high water, protects the public highway and adjacent private property from storm damage and severe flooding, and

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provides a shore line promenade. In addition, groins constructed to prevent shoaling in the existing dredged boat basin will provide protection to small boats and to two yacht clubs. Evaluated benefits comprise elimination of annual costs of repairs of public and private property due to storm attack and flooding, elimination of extensive repairs required on existing structures, increases in private property values, and the worth of the beach facilities to the general public. Monetary values have not been placed upon such benefits as the increased value of public property, the public asset provided by the creation of a beach promenade, or the protection offered the yachting interests by the two groins.

69. The proposed plan of improvement and protection will protect public property and will further provide for the encouragement of healthful recreation of the people. The shore to be protected is owned by the Metropolitan District Commission of the Commonwealth of Massachusetts. The public interest in the protection and improvement of Quincy Shore has been found to be substantial. The protection and improvement of the publicly-owned beach and property and the degree of public interest in such work are considered sufficient to justify the full one-third Federal contribution to the first cost of the plan of improvement authorized by the general provisions of Public Law 727.

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IX. DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

70. Coordination With the Cooperating Agency. - The results of the study of Quincy Shore and the recommended improvements have been discussed with the engineering representatives of the cooperating agency, who approved the plan of improvement.

71. The cooperating agency has been advised of requirements set forth in Paragraphs 86 and 87, which must be met by local authorities in the prosecution of projects in which the Federal Government participates. The cooperating agency has already accepted similar conditions as applied to the improvement at Winthrop Beach recommended under the cooperative study and contained in the report on Winthrop Beach, published in House Document No. 764, 80th Congress, 2nd Session.

72. Coordination With Yachting Interests. - In view of extensive use of Quincy Bay by yachtsmen and the need of protecting their interests, a meeting was arranged with the Commodores, other officers and members of the Wollaston and Squantum Yacht Clubs, at which full details of the proposed improvements were presented and discussed. The expressed opinions of both clubs were that the recommended improvements would not interfere with the maneuvering of boats in the vicinity of the clubs or interfere with yachting in any way. They felt that the jetties would offer protection to the yacht club piers from both storms and floating ice and would provide a safe anchorage for small boats. The clubs also believed the confinement of Sachem Creek across the beach would reduce the silting of their mooring basins.

73. Discussion. - The present shore line at the head of Quincy Bay is an artificial shore line resulting from the construction, in 1905, of a highway across the marshes, beach and hummocks in the area. Prior to

1905, the shore line was indefinite with marshes generally separating the ocean from the hummocks and fastland in the area. Though there were deposits of material available for beach building, the weak currents in the bay were generally unable to reach them and only one short beach was developed at the head of the bay. The present beach is the result of tidal action on the highway embankment, there being no definite program of artificial beach building.

74. The highway embankment was low, having top elevations varying from 0 to 1 foot above the height of maximum recorded high water, and was generally located near or seaward of the then existing mean high water line. The location and height of the embankment, above the marsh, resulted in the erosion of the embankment and necessitated construction of protective structures. Two short sea-walls were erected in 1910 to protect exposed portions of two hummocks, and these walls have been relatively successful. The main shore protection was constructed in 1926, and comprises a stepped concrete sea-wall varying in height today from about 0.7 feet below to 1.3 feet above the elevation of maximum recorded high water. Since the stepped wall was constructed, beach elevations adjacent to the wall have been generally lowered from 1.5 to 5.4 feet and the wall is undermined at certain points. The wall has not proven successful in protecting the highway and adjacent property. Waves top the wall, wash out the adjacent roadway and parking area, and flood large residential areas. The wall has not proven adequate in resisting the forces attacking it, and it has been necessary at four different periods to rebuild large sections. The wall today is in an extremely poor condition and requires extensive repairs and rebuilding. In an attempt to prevent flooding of the highway and adjacent lowlands,

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a 4-foot high parapet was constructed on the northerly 1130 feet of the stepped sea-wall in 1948. This parapet will be of no value unless it is tied to high ground.

75. The beach being contiguous to a large permanent residential area, and bordered by a good highway and free parking areas, has developed into a principal recreational beach, though beach conditions were generally adverse to such a development. The beach, composed of materials which are generally coarse sand and gravel, is only about 100 feet wide above the mudline, and is almost inundated during the higher tides. The water is polluted by raw sewage discharged into Boston Harbor, though this condition will be rectified through the current construction of a sewage treatment plant at Nut Island, and proposed plants at Moon and Deer Islands. A discussion of pollution, and its rectification, is contained in Appendix I. The popularity of this beach for bathing has resulted in local interests seeking legislative action to improve it for recreational use, both by sanding the beach, and eliminating all pollution. Legislative action has also been sought to provide additional shore protection.

76. The beach requires nourishment to arrest erosion, which endangers the shore line structures and highway, and to provide a more suitable recreational beach. The highway and adjacent property, require more protection from storm waves attacking the shore. There is no possible source of natural nourishment for this beach and all materials must be artificially supplied. The stepped sea-wall has been unsuccessful in resisting attacking forces, and in protecting the highway and adjacent area. It is not feasible to reconstruct this wall, or to extend the parapet

on the wall, but the wall may be advantageously incorporated as the core of another type of protective work.

77. The proposed plan of improvement consists of (a) the artificial placement of fill to build a beach wide enough to dissipate the energy of waves attacking the shore, and to provide adequate recreational area for the people using the beach; and (b) the construction of a bulkhead and concrete sea-wall to prevent beach materials washing onto the highway, and high waters flooding the road and adjacent property in areas where protective structures are not high enough. The bulkhead would be located in front of that part of the stepped sea-wall on which no parapet has been constructed, and would utilize the sea-wall as a relief from loads from the highway embankment, and as a backing in the event the beach is ever eroded. The stepped sea-wall also would be utilized as the foundation of a walk to provide passage to steps leading onto the beach. This walk is a definite improvement in the beach development since no promenade at present exists on the seaward side of the highway. The concrete sea-wall would extend the existing bulkhead northerly to high ground.

78. The artificial placement of fill on the beach involves the extension of drainage structures presently discharging on the beach, the control of the discharge channel of Sachem Creek by construction of a culvert, and the construction of two jetties to maintain the fill in the area of the yacht clubs, and to protect the dredged mooring basin from filling in. The extensive mud flats fronting the existing beach contain clams which are dug by both local residents and com-

mercian fishermen. The recommended fill will cover a small portion of the clam beds.

79. In view of the failure of littoral currents to build a beach in the area, and the apparent reversal of such currents in direction, it is not considered that groins are necessary to maintain the fill outside the yacht club area. Proper maintenance of the beach may be accomplished through periodic grading and replenishment of artificial fill.

80. The total cost of the proposed plan for Quincy Shore is \$849,000. The shore to be protected and improved is owned by the Metropolitan District Commission of the Commonwealth of Massachusetts. The public interest in the protection and improvement of the beach has been found to be substantial. It is considered that if economically justified, the protection and improvement of this publicly-owned beach and the degree of public interest therein are sufficient to justify the full one-third Federal contribution toward the first cost of the proposed project, as authorized by the general provisions of Public Law 727, 79th Congress, 2nd Session. The estimated Federal contribution would be \$283,000. The annual cost of the proposed plan is estimated at \$45,750.

81. Partially evaluated benefits to be derived from the plan amount to \$114,020. The ratio of evaluated benefits to annual costs is 2.5 to 1. Benefits discussed in Paragraphs 63 and 68 are found to be of sufficient value to justify the cost of the project. These benefits include the protection and preservation of public property, and the development and improvement of recreational facilities. The benefits to be realized from the project are found to be 63 percent public, and 37 percent private.

82. Conclusions. - The Division Engineer considers that the best plan for preventing further erosion, stabilizing and improving the beach, and protecting sea-walls and other public property at Quincy Shore should provide for the improvement of the beach by the artificial placement of sand fill, and the construction of a bulk-head and a sea-wall, together with necessary extension of drains, and construction of groins, culvert, and walk, as shown on Plate C-3. The Division Engineer concludes that the above construction is warranted.

83. The sewage treatment plant for the South Metropolitan District System, now nearing completion at Nut Island, will correct pollution in Quincy Bay to an extent that the Quincy Shore Beach will be generally safe for bathing. Complete elimination of pollution in Quincy Bay to make the beach safe for bathing at all times is dependent upon the construction of a treatment plant for the Boston Main Drainage System, plans for which have already been completed.

84. The proposed work is new construction and is primarily for the protection of publicly-owned shores. It therefore meets the requirements for Federal participation in the first cost of construction of works for the improvement and protection of the shore. The nature and amount of public benefits are sufficient to warrant the maximum one-third participation by the United States in the first cost of the proposed new construction, as permitted by Public Law 727, 79th Congress, 2nd Session.

85. Recommendations. - It is recommended that the Commonwealth of Massachusetts adopt a project for the protection and improvement of Quincy Shore Beach to the extent of:

- a. Improving the beach between Hovey Street and Rufe's Hummock

Sea-wall, a distance of 8500 feet, by placing approximately 126,000 cubic yards of sand and gravel, and 221,500 cubic yards of sand thereon, to provide a backshore elevation of 15.0 feet above mean low water;

b. Constructing a concrete-encased steel sheet-pile bulkhead between the parapet wall, near Hollis Avenue, and the National Sailor's Home Hill Sea-wall, a distance of 4750 feet, having a top elevation of 18 feet above mean low water;

c. Constructing a concrete sea-wall in extension of the parapet wall to high ground at Billings Street, a distance of 325 feet, having a top elevation of 19.2 feet above mean low water;

d. Constructing an impermeable stone groin, 200 feet northerly of the Squantum Yacht Club, and a similar groin 200 feet southerly of the Wollaston Yacht Club, each groin being 350 feet long and generally 2 feet above the highest adjacent fill;

e. Constructing a paved walk behind the recommended bulkhead for a distance of 4750 feet, and;

f. Constructing a culvert at Sachem Creek, and extending existing drains across the beach to discharge seaward of the recommended fill, all at an estimated initial cost of \$849,000 and \$7,000 annually for maintenance.

86. It is recommended that the United States adopt a project for the protection and improvement of the shore between Hovey Street and Rufe's Hummock Sea-wall, by authorizing participation through the contribution of Federal funds in an amount equal to one-third of the first cost of construction of the project. The project con-

sists of the work described in Paragraph 85, and its cost to the United States is estimated to be \$283,000. Contribution of Federal funds shall be made contingent upon approval by the Chief of Engineers of the detailed construction plans and specifications, and the arrangements for the prosecution of the new work prior to its commencement.

87. It is further recommended that the contribution of Federal funds shall be also contingent upon agreement with the Commonwealth of Massachusetts providing that the Commonwealth will:

a. Maintain and repair the works as may be required to serve the intended purpose, including periodic replenishment of the artificial fill on the beach;

b. Provide free of cost to the United States, all lands, easements, and rights-of-way necessary for the initial work and subsequent maintenance;

c. Hold and save the United States free from claims for damages connected with or resulting from the work;

d. Furnish assurance that pollution in Quincy Bay that would be harmful to bathers, will be eliminated.

JAMES H. STRATTON
Colonel, Corps of Engineers
Division Engineer

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APPENDIX I

POLLUTION AND ITS ELIMINATION IN BOSTON HARBOR

1. Existing Sewerage Systems. - a. General. - Corrective measures are being taken to rectify the pollution of Boston Harbor existing as a result of present sewerage systems. Raw sewage is presently discharged into Boston Harbor at the rate of 200,000,000 gallons per day. This sewage is collected by three systems serving thirty-three towns and cities. There are twenty other communities, most of which lack sewerage systems, which in the future may be connected to the sewers discharging into Boston Harbor. The three systems are designated as the South Metropolitan District System, the Boston Main Drainage System, and the North Metropolitan District System.

b. Boston Main Drainage System. - The Boston Main Drainage System is owned by the City of Boston and serves the older parts of the city. The sewage is passed through a 2-3/4-inch screen and discharged on outgoing tides into the harbor from outlets at Moon Island at the northwest entrance to Quincy Bay. Storage tanks are provided so the discharge may be made so far as practical during the 2nd and 3rd hours of the falling tide.

c. South and North Metropolitan District Systems. - The South and North Metropolitan District Systems are owned by the State and serve the areas north, west, and south of Boston. The south system discharges sewage, after coarse screening, through three outlets northwest of Peddocks Island at the southeast entrance to Quincy Bay. The north system discharges coarse screened sewage through multiple outlets near Deer Island Light on the northeast side of the main ship channel into Boston Harbor.

2. Public Investigations of Pollution. - The discharge of raw sewage into the harbor has long been a cause of public concern and objection, and

seven legislative investigations have been made since 1900. The last investigation was made in 1939 and a report thereof was published in House Document 2465 (Massachusetts General Court). This report deals with pollution in the harbor and tributary streams, and the design of the three sewerage systems. The conclusions of consultants employed in the investigation are:

"(a) Slick and sewage fields now extend over large portions of Boston Harbor and penetrate Quincy Bay and Hingham Bay. In these bays the sewage fields have reached points less than one-half mile from shore in many places.

(b) The bacterial content of the shore waters of the harbor, as evidenced by the B. coli index in some places, is at times higher than what is generally considered a reasonable upper limit for the safety of bathing beach water.

(c) While the beaches in general are not seriously affected by grease balls and other visible objects of sewage origin, stranded along the shore, there are evidences that such pollution does occur and with sufficient frequency to lower the desirability of some of the bathing beaches for recreation."

The Special Commission in its report of the investigation found in part:

"That Boston Harbor, Quincy Bay, and Hingham Bay and tidal estuaries are polluted."

"That streams tributary to Boston Harbor are polluted."

"That a potential health menace exists in these waters as a result of pollution."

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"That the danger to public health will increase rather than decrease if pollution is not checked."

"That pollution of Boston Harbor must be stopped."

"That there is a widespread demand for corrective action."

The Commission recommended in part:

"That treatment works be constructed at the three outlet works in Boston Harbor to reduce pollution in Boston Harbor, Quincy Bay, Hingham Bay and their tidal estuaries."

"That overflow conduits be constructed in our inland systems to prevent pollution in streamtributary to Boston Harbor."

Plans of the proposed works were submitted with the recommendations.

3. Pollution of Waters Along Quincy Shore. - Inspection of maps show the proximity of Quincy Shore to the outlets of the Boston Main Drainage and South Metropolitan District Systems. It is not believed that the Deer Island outlet greatly affects Quincy Shore. The beach has been declared safe for bathing by the Massachusetts Department of Health after analysis of water samples. This Department uses the widely accepted standard that water containing not over 1000 coliform bacteria per 100 c.c. of water is safe for bathing. This department is without authority to prevent the use of polluted waters for bathing, but upon request, tests the water for pollution. Quincy Shore is tested quite frequently during the bathing season. Though periodic tests show the beach safe from pollution, there are times when adverse winds (those having northerly components); adverse tidal currents; and improper operation of discharge valves at Moon Island cause polluted conditions at the subject beach. At other times while the water itself may be safe for bathing, objectionable floating matter renders the beach

undesirable. Such an occurrence is reported under Boston Harbor Investigations for 1935-1936. On August 6, 1936, Wollaston Beach was examined at flood tide while a northeast wind was blowing. The water close to shore was very dirty and contained debris, but it was impossible to determine if the sewage field touched the shore.

4. Pollution of Mud in Quincy Bay. - The deposits on the floor of Boston Harbor have become polluted by the settlement of floating sewage solids. Investigations made in 1935 and 1936 showed that at many harbor and shore stations, the mud samples exhibited many more bacteria characteristics of pollution than did the water above the mud. It was thought that this condition was due to the water being changed each tidal cycle while the deposited solids were not washed away. The muds in the entrance to Quincy Bay in the path of the flood tide from Nut Island, and the muds near Wollaston and Squantum Yacht Clubs were particularly polluted. Pollution of the shore mud has seriously affected the shell fish industry along Quincy Shore.

5. Effect of Pollution on Bathing at Quincy Shore. - The safety of bathing at Quincy Shore at present is of a doubtful nature. While it is generally safe for bathing, there are periods when it is definitely dangerous to public health. At other times, debris left in wave wash, while not serious from a health point of view is detrimental to the proper enjoyment of the beach.

6. Corrective Action Initiated by State and City. - a. Construction of Treatment Works for South Metropolitan District System. - The State and the City of Boston have taken positive action to correct the pollution of Boston Harbor, by initiating a program of corrective works similar to those recommended in the report of the last special investigation -- House Document 2465. The principal difference between the proposed works and recommended works is that sludge will be pumped to deep water in lieu of being barged to sea. The first unit of this program, the treatment works

at Nut Island for the South Metropolitan District System, is under construction and is scheduled for operation in 1950. Upon completion of the project, the sewage will pass through sedimentation tanks to remove the solids and grits. The effluent will then be discharged through the existing outlets near Peddock's Island and during the bathing season will be disinfected with chlorine to prevent the pollution of the harbor waters. The removed solids will be aerated and digested to form a sludge which will be held in storage tanks until ebb tide and then pumped through a new pipe line to the main 40-foot ship channel at a point near Deer Island Light. The sludge, reduced to 0.1 of 1% of its original volume and containing 92% water will be released through diffusing outlets in high velocity channel currents which will carry it far out to sea. It is not considered that any of the sludge will enter the harbor at any time.

b. Design of Treatment Works for Boston Main Drainage System. -

The City of Boston has engaged an engineering firm to design a similar plant for the Boston Main Drainage System. The preliminary plans were approved by the State Department of Public Health, which department must approve all sewerage systems in the state, and, final design of the plant has been completed. When the plant is constructed, the effluent will be discharged at Moon Island and will be disinfected during the bathing season. The sludge will be pumped into the new pipe line being built from Nut Island and will be discharged with the sludge from the South Metropolitan District System. The City of Quincy and the neighboring Towns of Braintree and Weymouth are taking all possible action to enforce the construction of the treatment plant.

c. Design of Treatment Works for North Metropolitan District System. - The State of Massachusetts has appropriated funds for the design of similar works for the North Metropolitan District Sewerage System, and work has been commenced on the design. When the works are constructed, the effluent will be discharged through the present outlets.

and will be disinfected during the bathing season. The sludge will be discharged into the main ship channel near Deer Island Light.

d. Improved Conditions to be Obtained from Proposed Works. - It is expected that the construction program will be completed in about eight years at a cost of \$20,000,000 to \$25,000,000. The completion of these works will correct most of the pollution in Boston Harbor. Fluids will be disinfected to provide safe bathing during the summer seasons, and solids and grease will be removed at all times. Improvement of the conditions of harbor deposits are to be expected under such a program. Other sources of pollution within the entire harbor will continue to exist; namely, those of industrial waste and private sewers. It is expected that elimination of these sources of pollution will be accomplished by public demand after the public sewage problem has been eliminated. There is no single industry in Boston which creates great problems like the stockyards and packing houses of Chicago or tanneries in Milwaukee. The industries are diversified. Furthermore, the locations of industrial plants and private sewers are such that they have no material effect upon Quincy Shore.

7. Effect of New Treatment Works on Quincy Shore. - The immediate construction of treatment works for the South Metropolitan District will eliminate the greatest source of pollution along Quincy Shore, since, at present, sewage is discharged at all tidal stages from this system. It is not believed that the discharge from the Boston Main System has as great an effect upon Quincy Shore. The outlets of the Boston Main Drainage System are on the northwest side of Moon Island, which is the opposite side from Quincy Bay. House Document No. 1215 of the Massachusetts General Court reports that investigations made in 1917 failed to show that sewage or suspended matter, excepting very light matters like grease balls, was carried from Moon Island outlets to the shore of Quincy Bay. House Document No. 1600, published 1937, stated that the results of numerous float tests show, "that sewage released at Moon Island on the outgoing

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tide under the present program may be expected to pass generally in a northeasterly direction between Rainsford Island and Long Island, but under certain conditions some of the sewage will pass between Long Island and Spectacle Island." Under proper and normal operation, sewage from Moon Island outlets does not affect Quincy Shore. During abnormal periods such as heavy storms, the capacity of storage tanks at Moon Island may be reached and release of sewage may be necessary at times other than those of normal release. At such times, sewage will probably reach Quincy Shore, but the beach would not be used for bathing during such periods. The completion of the treatment plant for the South Metropolitan District will correct pollution of Quincy Shore to an extent to make the beach generally safe for bathing at all times and the completion of a similar plant for the Boston Main Drainage System will eliminate all pollution at Quincy Shore.

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APPENDIX II

COST ESTIMATES FOR QUINCY SHORE

A. FIRST COSTS

Construction of bulkhead, jetties, culvert, walk and sea-wall, placement of fill, and extension of drains.

1. Construction of Bulkhead.

<u>a.</u> Steel Sheet-pile, 994 tons @ \$109.00	\$108,346
<u>b.</u> Reinforced Concrete, 1800 cubic yards @ \$30.00	54,000
<u>c.</u> Reinforcing Steel, 76,000 pounds @ \$0.12	9,120
<u>d.</u> Miscellaneous	<u>2,800</u>
Total Cost of Bulkhead	\$174,266

2. Walk.

<u>a.</u> Sand and Gravel Fill, 9,500 cubic yards @ \$1.35	\$12,825
<u>b.</u> Pavement, 1250 square yards @ \$2.50	<u>3,125</u>
Total Cost of Walk	\$15,950

3. Concrete Sea-wall.

<u>a.</u> Concrete, 350 cubic yards @ \$23.00	\$8,050
<u>b.</u> Steel Sheet-Piling, 4 tons @ \$109.00	<u>436</u>
Total Cost of Sea-wall	\$8,486

4. Groins.

<u>a.</u> Stone Core, 828 tons @ \$3.75	\$3,105
<u>b.</u> Stone Cap, 2708 tons @ \$4.50	12,186
<u>c.</u> Markers, 2 each @ \$50.00	<u>100</u>
Total Cost of Groins	\$15,391

5. Culvert for Sachem Creek.

<u>a.</u> Reinforced Concrete, Bulkhead	500
<u>b.</u> Culvert, 210 feet of 60-inch concrete pipe supported on concrete cradle and wood piles @ \$50.00	<u>10,500</u>
Total Cost of Culvert	\$11,000

6. Extension of Existing Drains.

a. Hollis St. Drain, 150 feet of concrete-encased, 36-inch concrete culvert pipe @ \$38.00	\$5,700
b. Drain at Profile F, 65 feet of two 24-inch cast iron pipes supported on piles @ \$37.00	2,405
c. Miscellaneous Pipe Drains, 375 feet @ \$9.00	<u>3,375</u>
Total Cost for Drain Extensions	\$11,480

7. Fill.

a. Sand, 221,500 cubic yards @ \$1.50	\$332,250
b. Sand and Gravel, 126,000 cubic yards @ \$1.35	<u>170,100</u>
Total Cost of Fill	\$502,350

RECAPITULATION OF COSTS

1. Bulkhead	\$174,266
2. Walk	15,950
3. Concrete Sea-wall	8,486
4. Groins	15,391
5. Culvert for Sachem Creek	11,000
6. Extension of Existing Drains	11,480
7. Fill	<u>502,350</u>
Total Construction Cost	\$738,923
Engineering and Contingencies	<u>110,077</u>
Total Cost	\$849,000

B. ANNUAL CARRYING CHARGES

1. Allocation of Costs.

The plan of improvement and protection of Quincy Shore Beach qualifies under the provisions of Public Law 727 for Federal participation to the extent of one-third of the first cost of the plan. The first cost of the

plan is therefore allocated as follows:

Federal Cost	\$283,000
Non-Federal Cost	<u>566,000</u>
Total First Cost	\$849,000

2. Federal Annual Carrying Charge.

a. Interest, 3% of \$283,000	\$8,490
b. Amortization of depreciation and obsolescence, estimated 40 years (283,000) (.01326)	3,750
c. Maintenance	<u>0</u>
d. Total Federal Annual Carrying Charge	\$12,240

3. Non-Federal Annual Carrying Charge

a. Interest, 3-1/2% of \$566,000	\$19,810
b. Amortization - 40-year period (\$566,000) (.01183)	6,700
c. Estimated Annual Maintenance*	<u>7,000</u>
d. Total Non-Federal Annual Carrying Charge	\$33,510

*Based upon estimated quantities required to maintain sand-fill and groins at design slopes and grade. The estimate of the quantity of sand replenishment is a conservative estimate based upon the rate of erosion experienced on the beach and the effect of the two jetties in maintaining the fill.

Sand-fill, 3500 cubic yards @ \$1.50	\$5,250
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Repairs to bulkhead, groins and drainage structures	<u>750</u>
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Total	\$6,000
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Engineering and Con- tingencies	<u>\$1,000</u>
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Total	\$7,000
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4. Total Annual Carrying Charge.

Federal Annual Carrying Charge	\$12,240
Non-Federal Annual Carrying Charge	<u>33,510</u>
Total Annual Carrying Charge	\$45,750

APPENDIX III

ANNUAL BENEFITS FOR QUINCY SHORE

1. Average Annual Direct Damages Prevented. -

a. Federal	\$ 0
b. Non-Federal Public	
(1) Storm Damage Repair by Metropolitan District Commission	7,000
(2) Annual Charges for Required Major Wall Repairs*	4,850
c. Private	<u>0</u>
Total Direct Damages Prevented	\$11,850

*Wall Repairs. - The existing wall is in need of major repairs, the accomplishment of which will be eliminated by the proposed plan. It is estimated that these repairs will cost \$103,500. Annual charges computed at 3.5 percent interest and amortized over a 40 year period is $\$103,500 \times (.035 + .01183) = \$4,850$.

2. Indirect Benefits. - Two areas adjacent to the beach are subject to flooding from storm waters passing over the sea-walls. One of these areas, Area A, is bounded by Hollis Avenue, Edwin Street, Faxon Road, E. Squantum Street and South Bayfield Street. The second area, Area B, is bounded by Sachem Street, Franklin Avenue, Copley Street and Rice Road. The 4-foot parapet wall constructed in 1948 along the northerly end of the low stepped wall passes in front of critical Area A ending 50 feet from the southerly limit, Hollis Avenue. This parapet will protect the area from direct wave attack, but flooding will still occur in the area due to high water passing around the ends of the parapet. The proposed project will eliminate all flooding in both critical Areas and a benefit will be derived through the elimination of expenditures now annually made in the repair of flood damages. In Area A, it is estimated the parapet has reduced past annual expenditures by 75 percent. The annual expenditures to be eliminated are:

a. <u>Federal</u>	\$ 0
b. <u>Non-Federal Public</u>	
Area A, City of Quincy	2,000
Area B, City of Quincy	4,000
c. <u>Private</u>	
Area A	1,000
Area B	<u>2,000</u>
Total Indirect Benefit	\$9,000

3. Increased Property Values Resulting from Shore Protection. -

Frontal property adjacent to Quincy Shore Reservation will increase in value as the result of protection from storm attack, and marginal property (property lying in the rear of the property immediately fronting the reservation) in the two critical areas will increase in value as the result of the elimination of flooding of such property. In non-critical areas it is estimated that frontal property values behind the parapet will increase 5 percent and elsewhere 10 percent. In critical area A, now partially protected by the parapet, it is considered that both frontal and marginal property will increase 10 percent in value. In critical area B, it is estimated that the frontal property values will increase 60 percent and marginal property values will increase 50 percent. These increases result in benefits to the non-federal public which may be realized as tax returns on increased valuations. The 1948 tax rate in Quincy is \$38.00 per \$1000 of valuation. While the private benefit may not be realized until the property is sold, the benefit may be measured as interest on the gains at the rate of 3.5 percent. The benefits to be realized are as follows:

a. <u>Federal</u>	\$ 0
b. <u>Non-Federal Public (Tax Increases)</u>	
(1) <u>Critical Area A</u>	

(a) Frontal Property

$$\$99,800 \times .10 \times .038 = \$ 380$$

(b) Marginal Property

$$\$459,600 \times .10 \times .038 = 1,750$$

(2) Critical Area B

(a) Frontal Property

$$\$24,600 \times .60 \times .038 = 560$$

(b) Marginal Property

$$\$796,700 \times .50 \times .038 = 15,140$$

(3) Non-Critical Areas

Frontal property has an aggregated length of 4050 feet and assessed valuation of \$305,400. Property behind parapet wall has a length of 600 feet.

(a) Frontal Property Behind Wall

$$\frac{600}{4050} \times \$305,400 \times .05 \times .038 = \$ 90$$

(b) Frontal Property Outside Parapet Protection

$$\frac{3450}{4050} \times \$305,400 \times .10 \times .038 = 990$$

c. Private (Interest on Capital Gain)

(1) Critical Area A

(a) Frontal Property

$$\$99,800 \times .10 \times .035 = \$ 350$$

(b) Marginal Property

$$\$459,600 \times .10 \times .035 = 1,610$$

(2) Critical Area B

(a) Frontal Property

$$\$24,600 \times .60 \times .035 = 520$$

(b) Marginal Property

$$\$796,700 \times .50 \times .035 = 13,940$$

(3) Non-Critical Areas

(a) Frontal Property Behind Parapet

$$\frac{600}{4050} \times \$305,400 \times .05 \times .035 = \$ 80$$

(b) Frontal Property Outside Parapet Protection

$$\frac{3450}{4050} \times \$305,400 \times .10 \times .035 = 910$$

d. Total

\$36,320

4. Recreational Benefits. - a. The present beach is stony and very narrow, being partially inundated at high tide. Patronage of this beach presently averages 1000 people per day, with peak crowds reaching 5000 people. Under peak conditions the beach is so crowded that it cannot accommodate the crowd and many patrons must use the sea-wall to sit on. The proposed project will provide a dry sandy beach generally 120 feet wide at mean high water for a length of 8500 feet. Allowing the desirable area of 75 square feet per person, the proposed beach will accommodate without crowding 13,600 people or approximately 2.7 times the present peak load. This improved beach will result in great recreational benefits, particularly in view of its presently established recreational use and its proximity to metropolitan populations.

(1) Federal. - Federal interests are not involved.

Federal Benefit

\$ 0

(2) Non-Federal Public

(a) It is estimated that because of the improved condition in respect to material and area and because of its accessibility and nearness to great metropolitan populations, this beach will receive patronage of 4000 people daily, representing an increase of 3000 people per day. Assuming that during a 10 week summer period 25 percent of the days are inclement, the minimum increased patronage will be:

$$3000 \times (10 \times 7) \times .75 = 157,500$$

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This increased patronage is due directly to new beach development and its net worth or public benefit may be evaluated in terms of fees which the patrons would be required to pay were the beach a private enterprise. The minimum fee which would be charged would be 10 cents per person. The benefit thus becomes:

$$157,500 \times .10 = \$15,750$$

(b) Private property will increase in value as the result of the improved recreational facilities. The increased valuations are discussed in the following subparagraph (3). The non-federal public will derive a benefit from the increased valuation through increased tax returns thereon. The increased tax returns will be as follows:

Frontal Property, Channing Street to Rice Road

$$\$224,700 \times .35 \times .038 = \$3,000$$

Balance of Area

$$\$8,664,800 \times .05 \times .038 = 16,500$$

(c) Total Non-Federal Public Recreational Benefit \$ 35,250

(3) Private Benefits. - (a) Recreational benefits to be derived by private property comprise increased earning power derived from the proximity to the improved beach. The frontal property between Channing Street and Rice Road is locally zoned for business use, and is generally given over to restaurants and refreshment stands, though other businesses such as a bowling alley, gasoline stations and a floor covering store exist in the area. Part of the property is used for residences and part of the land is unoccupied. Only the light refreshment stands are closed during the winter months. Because of the diversity of property use in the business area, it is estimated that 35 percent of the business possibilities is derived from summer beach patronage. While it is estimated that daily beach attendance will be increased four times, it is not considered that summer business will increase in the same proportion since many of the patrons will come from nearby areas and will not spend money at the stands. It is

conservatively estimated that summer business possibilities, estimated to be 35 percent of annual business, will be increased only two times. This increase represents a 35 percent increase in annual business. The return on business property investments is realized in the form of rentals which depend upon business possibilities. The benefit derived through increased business may be realized through increased rentals. Hence between Channing Street and Rice Road, the recreational benefit derived from beach improvement may be evaluated in terms of actual or possible increased rentals. The assessed valuation of frontal property between Webster Street and Fenno Street, a distance of 6300 feet, is \$429,800. The distance between Channing Street and Rice Road is 3300 feet. The assessed valuation of frontal property in the business zone becomes:

$$\frac{3300}{6300} \times \$429,000 = \$224,700$$

Assuming rental of property is 12 percent of the assessed valuation, the increased rental or gross benefit becomes:

$$\$224,700 \times .12 \times .35 = \$9,440$$

Deducting taxes of \$3,000 as computed in subparagraph 4-a-(2) above, the net private gain is \$6,440.

b. The balance of the area involved, bounded by Webster Street, East Squantum Street, Faxon Road, Rawson Road, Gould Street, Wendell Avenue, Rice Road, and Fenno Street, is principally a year round residential area, having an assessed valuation of \$8,664,800. (\$8,889,500 less \$224,700 valuation of business zone). Property in this area will increase in value because of three factors:

- (1) Personal enjoyment of residents in adjacent improved beach.
- (2) Increased returns available from room rentals during summer months.
- (3) Increased sales value to people desiring to live near a beach.

The monetary returns from the last two benefits may not be generally realized because the residents of the area may elect to maintain their property for their sole personal use instead of availing themselves of possible financial returns. However, the benefit to be derived may be evaluated as the interest, at 3.5 percent, upon the increased value of the property. It is estimated that possible recreational benefits will result in a 5 percent over-all increase in valuations in the area. This benefit is thus:

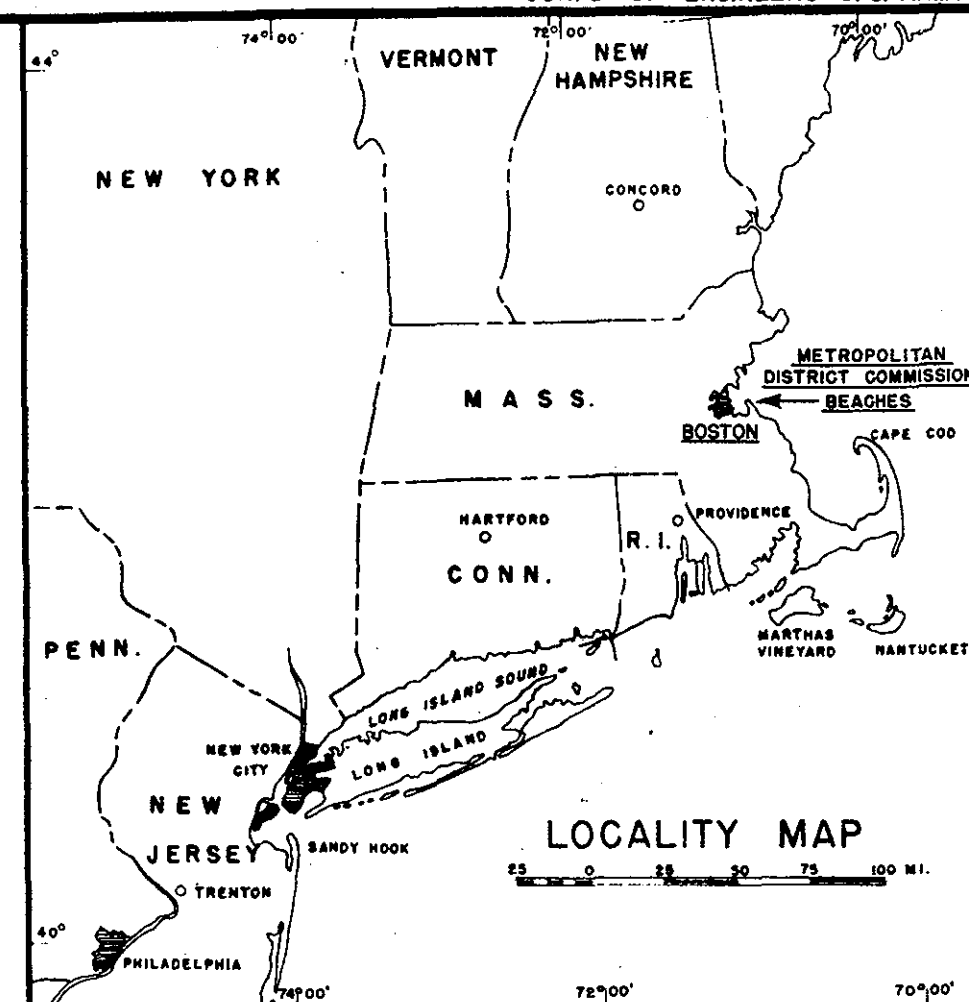
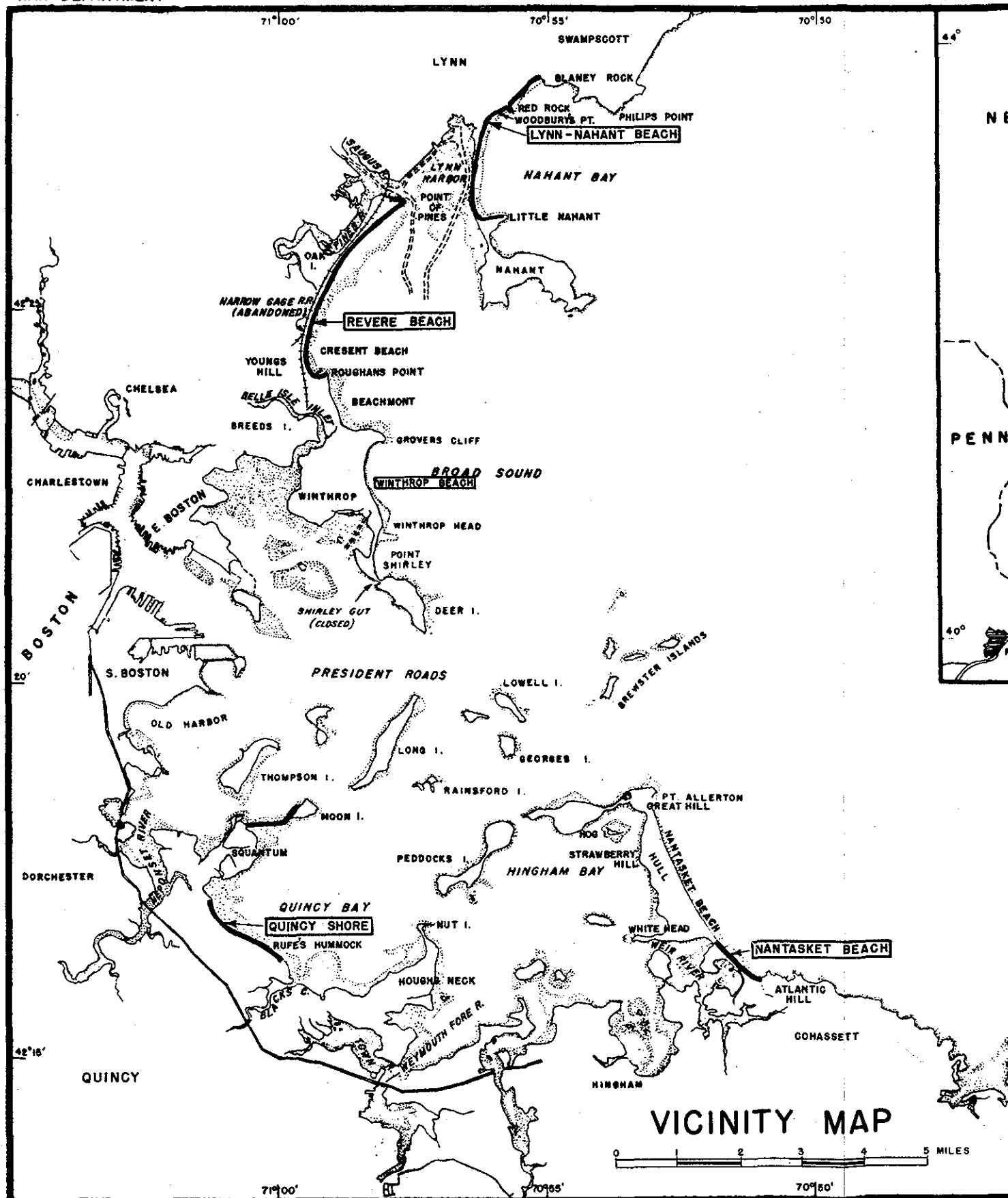
$$\$8,664,800 \times .05 \times .035 = \$15,160$$

c. Total Private Recreational Benefit = \$21,600

d. Total Recreational Benefits = \$56,850

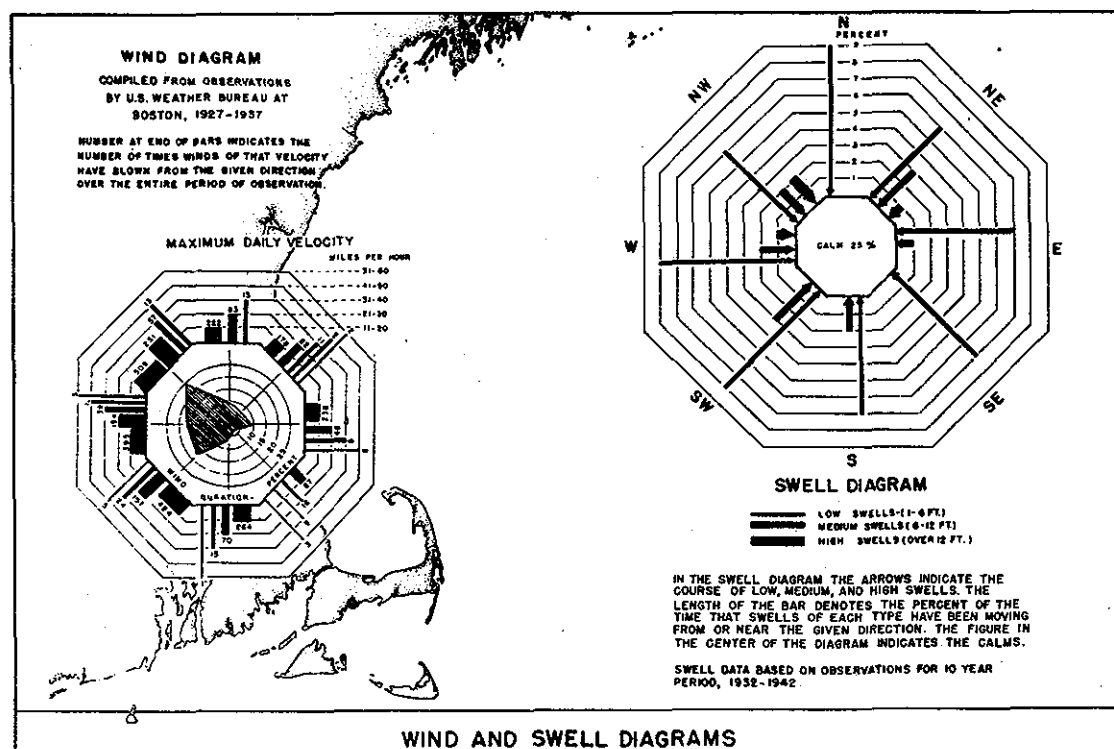
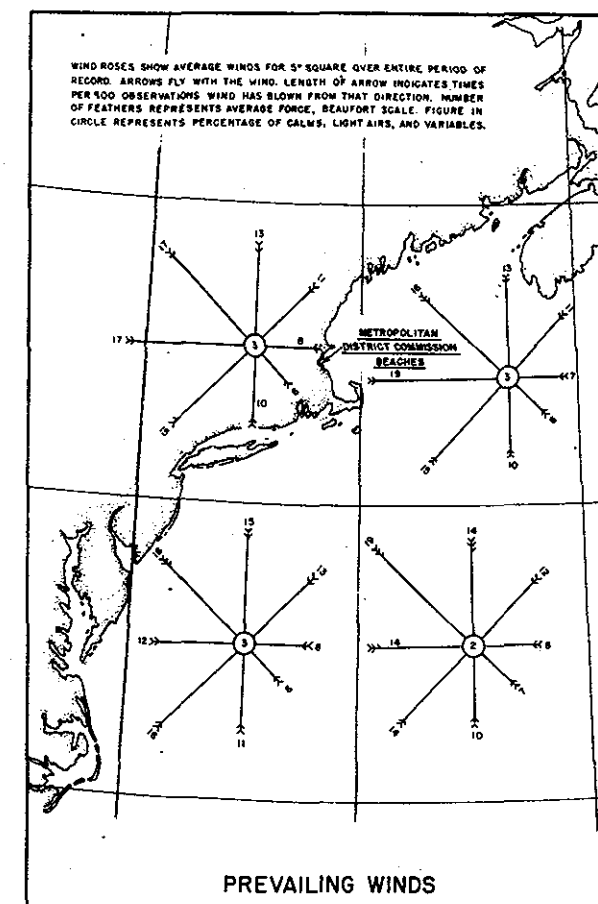
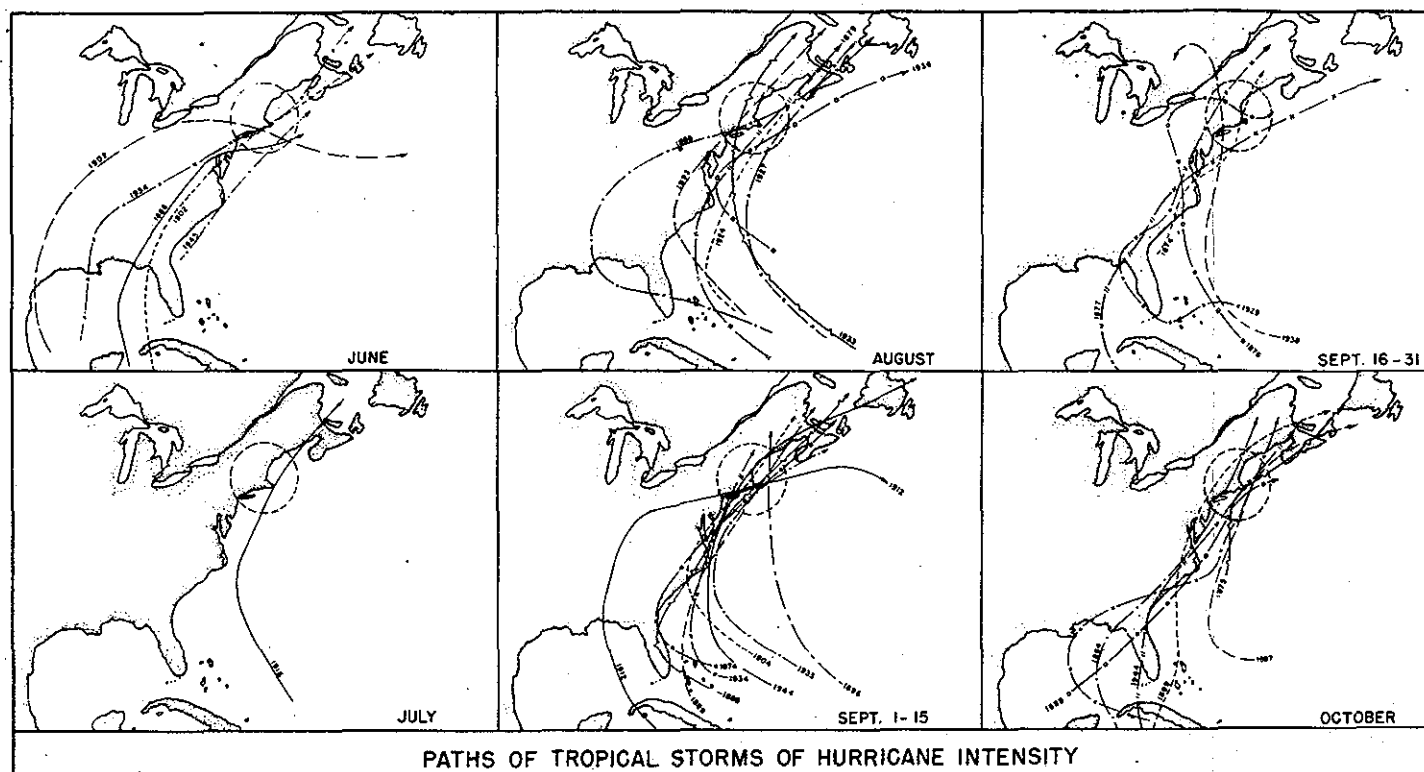
5. Total Benefits. - The total benefits evaluated herein are as follows:

<u>Type</u>	<u>Federal</u>	<u>Non-Federal Public</u>	<u>Private</u>	<u>Total</u>
Direct Damages Prevented	\$0	\$11,850	\$0	\$11,850
Indirect Benefits	0	6,000	3,000	9,000
Increased Valuation from Shore Protection	0	18,910	17,410	36,320
Recreational Benefits	<u>0</u>	<u>35,250</u>	<u>21,600</u>	<u>56,850</u>
Totals	\$0	\$72,010	\$42,010	\$114,020



To Accompany Report Dated: June 1, 1949.

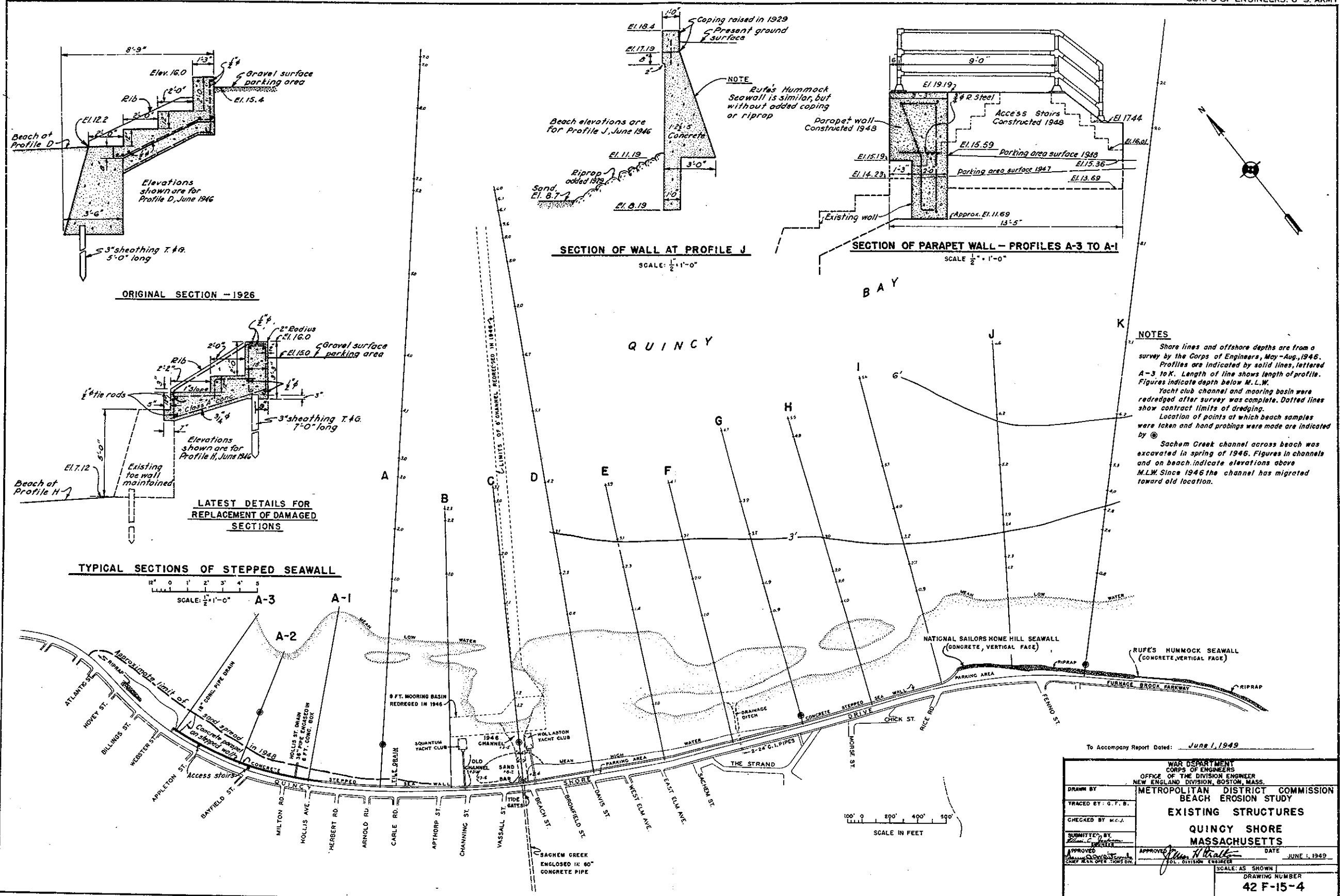
WAR DEPARTMENT CORPS OF ENGINEERS OFFICE OF THE DIVISION ENGINEER NEW ENGLAND DIVISION, BOSTON, MASS.	
METROPOLITAN DISTRICT COMMISSION BEACH EROSION STUDY LOCATION OF METROPOLITAN DISTRICT BEACHES, MASS.	
DRAWN BY: TRACED BY: R.J.B. CHECKED BY: SUBMITTED BY: APPROVED: <i>[Signature]</i> CHIEF, R.E.M. OPER. DIV.	DATE: MAY 27, 1949. COL. DIVISION ENGINEER
SCALE AS SHOWN DRAWING NUMBER 45 F-15-2	

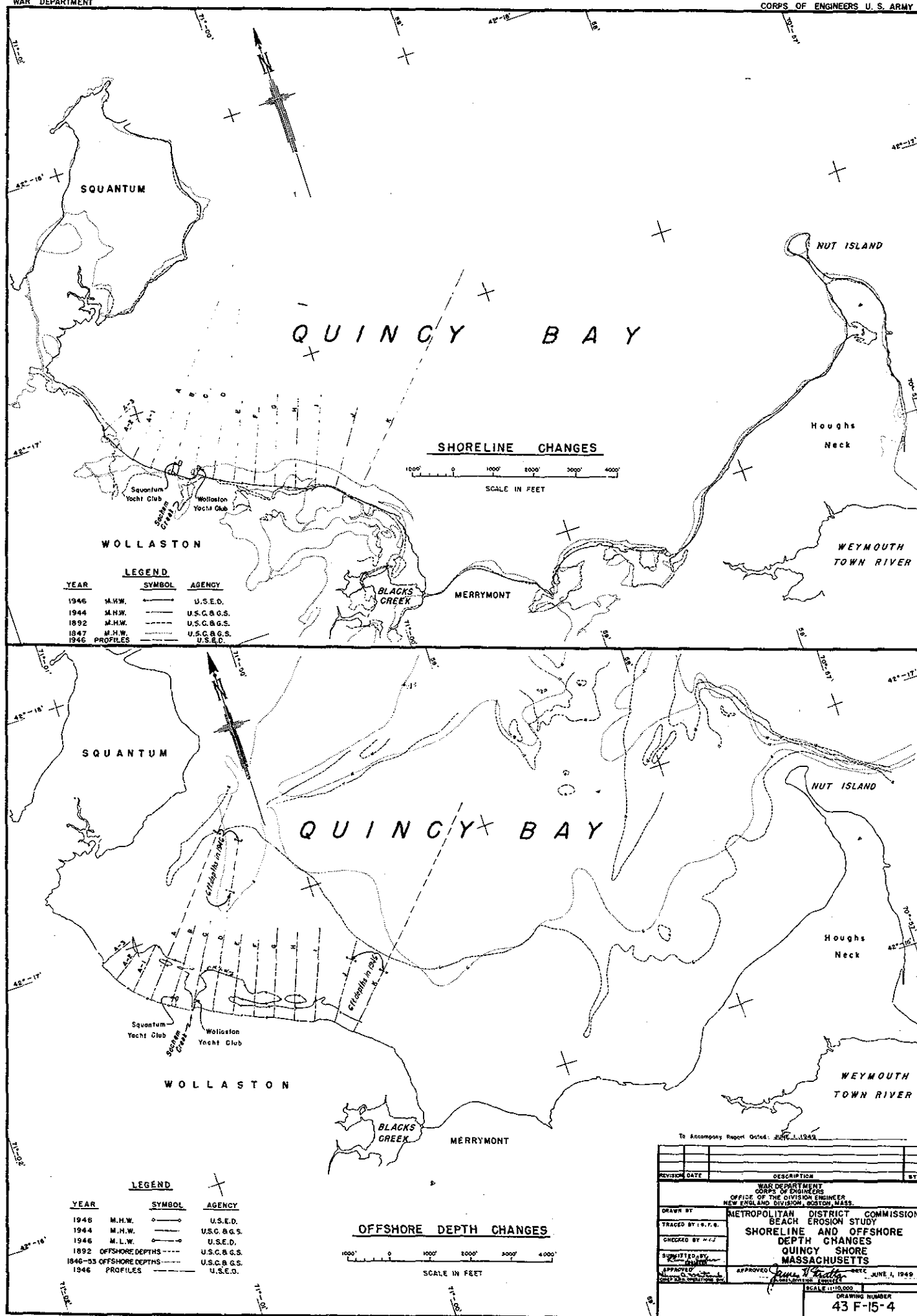


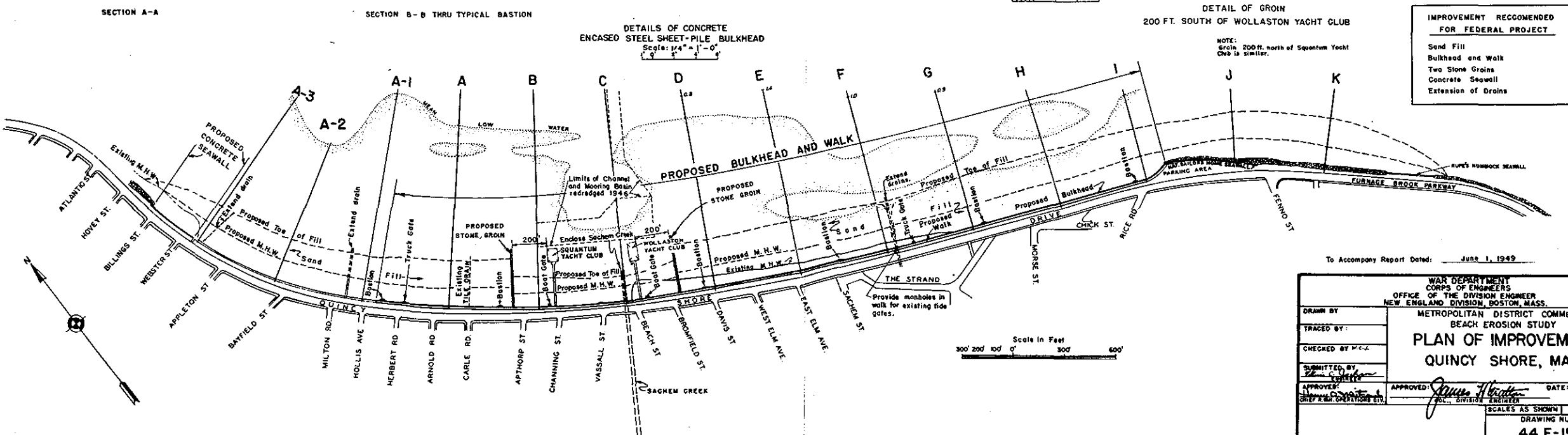
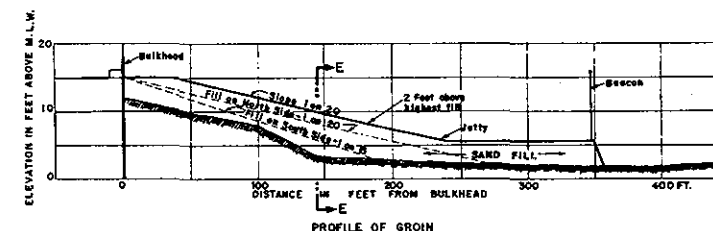
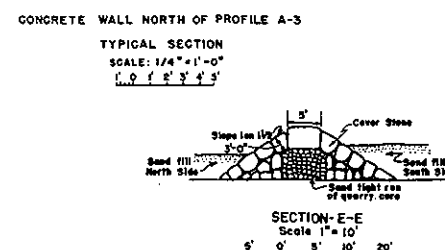
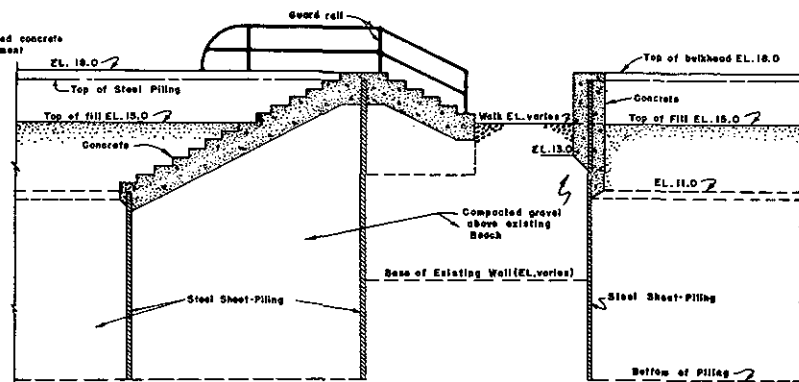
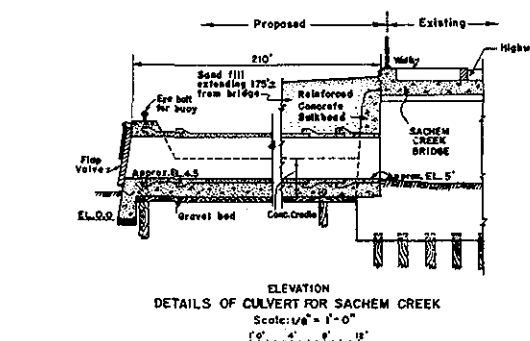
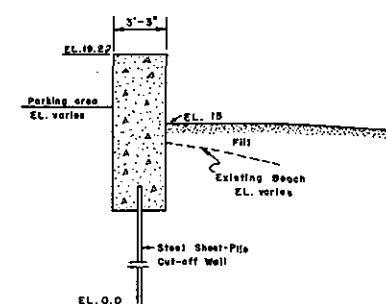
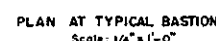
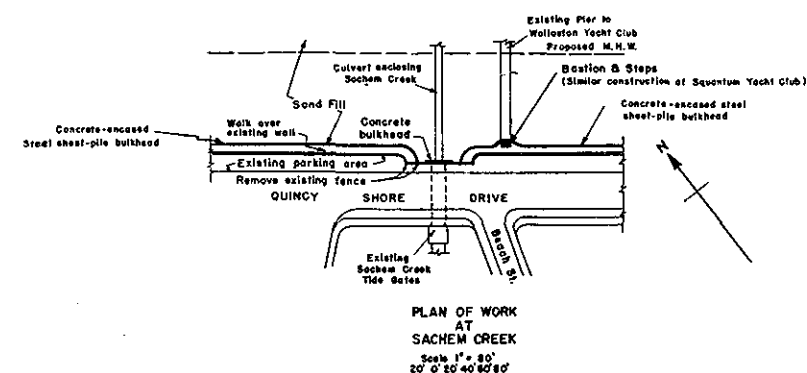
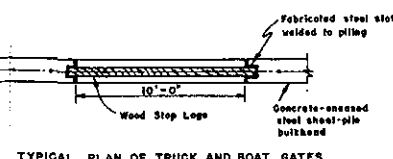
To Accompany Report Dated: June 1, 1949.

WAR DEPARTMENT CORPS OF ENGINEERS OFFICE OF THE DIVISION ENGINEER NEW ENGLAND DIVISION, BOSTON, MASS.	
METROPOLITAN DISTRICT COMMISSION BEACH EROSION STUDY	
WIND AND SWELL DIAGRAMS HURRICANES AND PREVAILING WINDS	
DRAWN BY	TRACED BY: R.S.B.
CHECKED BY	SUBMITTED BY
APPROVED	DATE
SCALE AS SHOWN	
DRAWING NUMBER 46-F-15-2	

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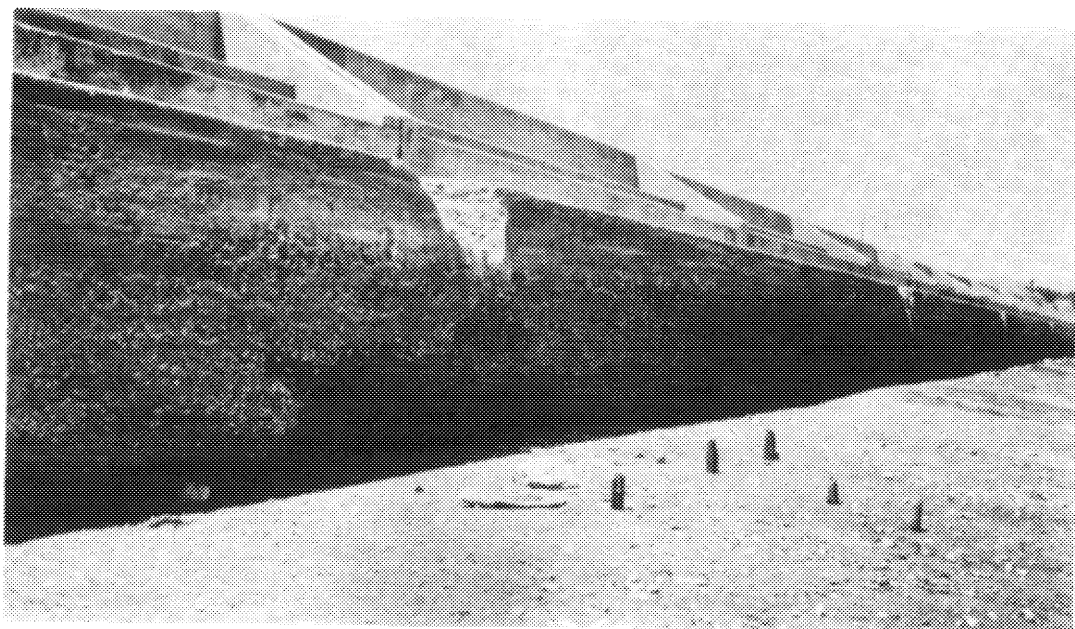




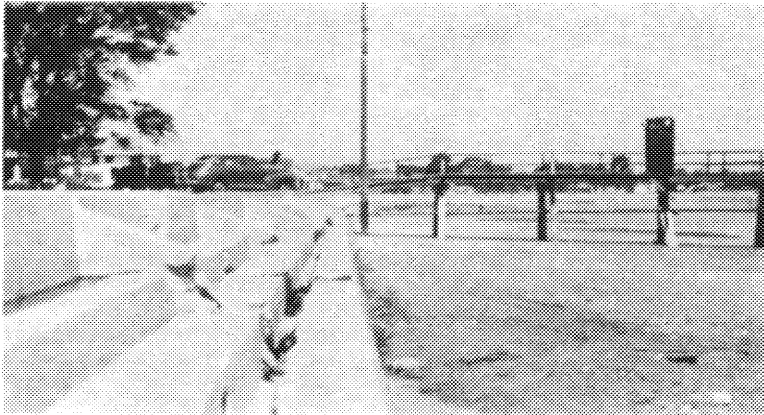




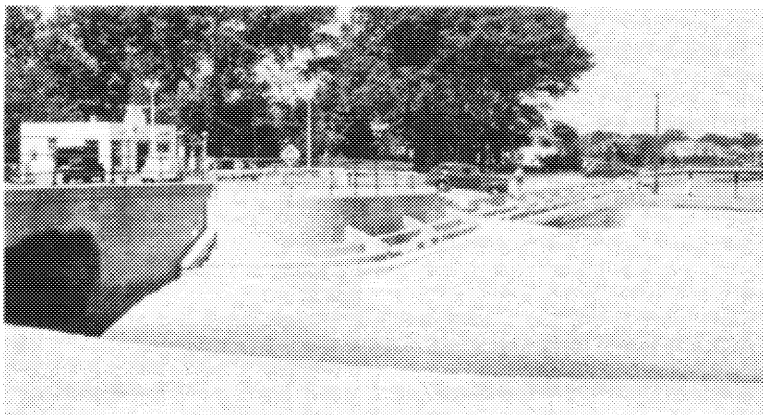
Northwest from foot of Herbert Road in March 1949, showing parapet recently constructed on top of stepped sea-wall. Sand on beach was artificially placed in 1948.



Stepped sea-wall at Profile A in June 1946, showing typical damage and undermining sustained by the toe wall section. Upper stepped section was reconstructed in 1937 and again in 1938.



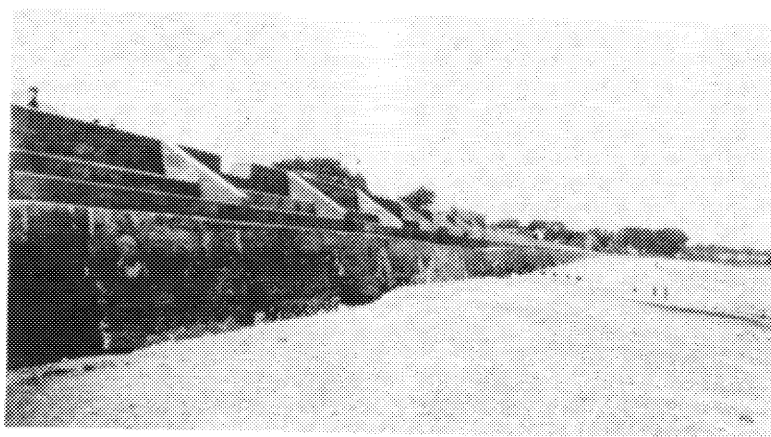
Wall north of Profile C, in June 1946. Typical of damage sustained by stepped section along entire beach.



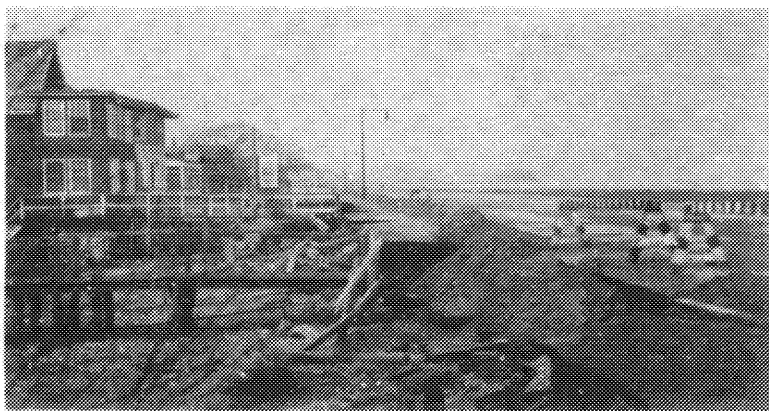
Sachem Creek in June 1946 after artificial channel was dug across beach. Note trace of old channel in front of wall and damage to north half of bridge opening.



South from Wollaston Yacht Club in August 1948.
Shows widest section of beach at high water during
high range of tides. Beach was graded against
wall in late spring.



Looking northwest from Profile I in June 1946.
Note damage to toe wall. Upper stepped section
was rebuilt in 1945 without repairs to toe wall.



Looking northeast from Profile I, showing washout on landward side of highway after northeast storm of November 28-30, 1945.



Looking north from Profile J in June 1946. Note toe wall added to base of vertical sea-wall.

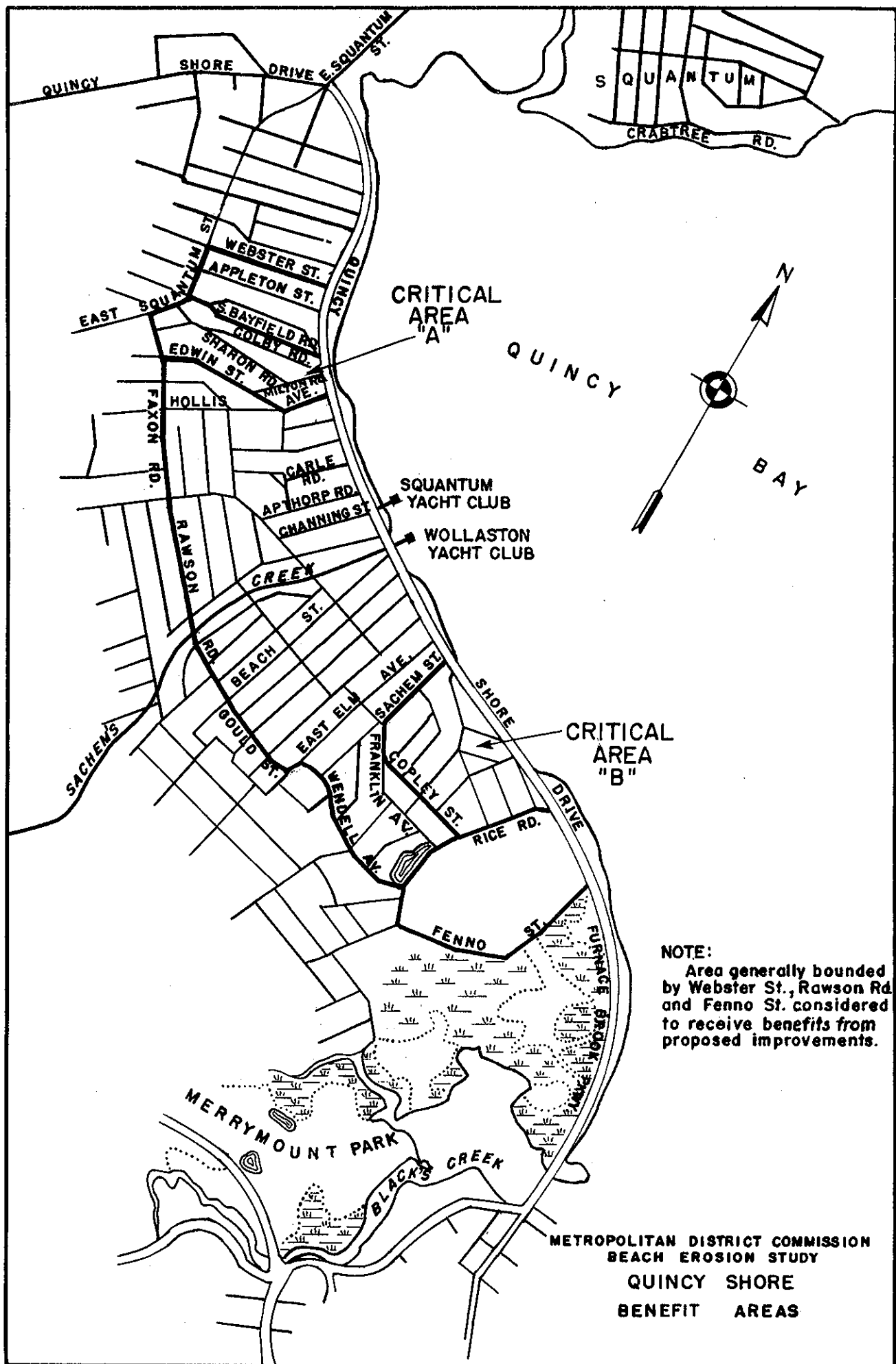


Fig.C-5